The Australian and New Zealand Journal of Surgery

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Royal College of Surgeons of England.

JACKSONIAN PRIZE.

THE Council of the Royal Australasian College of Surgeons has been advised by the Council of the Royal College of Surgeons of England that the subject chosen for the Jacksonian Prize for the year 1944 is as follows: "The Causation and Treatment of Delayed Union of Fractures of the Long Bones."

Full details governing the conditions of the prize may be obtained from the Secretary of the Royal Australasian College of Surgeons, Spring Street, Melbourne.

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THE AUSTRALIAN AND NEW ZEALAND JOURNAL OF SURGERY

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RESTORATION AFTER EXCISION FOR MALIGNANT DISEASE.[1]

By H. P. PICKERILL,
Wellington.

THE purpose of this short communication is to endeavour to show in what ways plastic surgery may be of assistance in the treatment of at least superficial malignant disease. The possibility of plastic restoration may well be borne in mind by the general surgeon when considering the best means of dealing with any superficial neoplasm. It is probable that wide and early excision is often considered but not adopted because of the fear of a subsequent large hiatus which it is thought might not be satisfactorily filled in. Without in any way wishing to enter the sphere of controversy as to the "best" way of treating such conditions, I should like to refer to an analysis by Warren and Hoerr[1] of 507 cases of pathologically verified epidermoid carcinoma of the skin, in which these authors show that five-year cures resulted in 53% of cases of excision as against 11% treated by radium in Grade I cases and 26% and 16% respectively in Grade II and Grade III cases. The mortality rates given are: excision 16%, radium 62% for Grade I, and 38% and 81% respectively for Grades II and III. This report did not include cases treated by the more recent Chaoul method, which would presumably now change these figures somewhat; but the report does undoubtedly establish the fact that a very large number of epidermoid carcinomata can be treated very successfully by wide and early excision.

There are, too, the not inconsiderable number of cases in which the neoplasm becomes resistant to radiation, and further radiation is either useless or harmful. In this type of case wide and deep excision offers the only hope of a cure.

There is also that further group of cases which arise occasionally when the radiation dose has been too heavy for the tissues and necrosis results. In these cases too treatment may be very satisfactorily carried out after a lapse of six months by wide and deep excision with restoration.

All malignant growths of the scalp should be widely excised, as there would seem to be a special tendency here for considerable lateral and invisible spread. If the pericranium is involved or is in the slightest degree adherent to the scalp, it too should be excised. When this has been done a free skin graft cannot be applied immediately of course. Two courses are open: (*a*) to remove the greater part of the outer table of bone and, by applying eusol, raise a quick crop of clean granulation tissue and graft onto this, or (*b*) to make restoration by a tube graft from the neck or abdomen.

[1] Accepted for publication on July 3, 1943.

Melanomata of the skin as soon as malignancy is suspected (or preferably before) are undoubtedly best attacked by very wide excision. These neoplasms are peculiarly liable to flare and to progress rapidly if touched by the knife, thermal agents or radiation.

Pathological examination often reveals malignant cells under the skin at some distance from any pigmented area. It would therefore seem to be a wise proceeding to excise these very malignant growths as early and as widely as possible. Even the smallest malignant melanoma should have a circle of at least two inches of apparently normal skin excised (see Figure I). Bickel, Meyerding and Broders have recently published a review of malignant melanomata occurring at the Mayo Clinic for twenty-four years.[2] They find that 29·8% of patients treated by excision (many of them in the early stages) survived five years or more, whereas none of the patients treated by irradiation survived for three years. They remark in conclusion: "Melanoepitheliomas may be present for long periods of time before the seriousness of their nature is determined or recognized, and their condition may be activated by meddlesome treatment."

FIGURE I. Showing size of excision and graft for a very small malignant melanoma, previously treated by both excision and diathermy. Biopsy had shown subcutaneous malignant cells nearly one inch from the little tumour.

Yet another type of malignant disease in which restoration may be considered is cancer of the breast. White in a recent paper[3] on this subject stated that in his opinion at least fifteen centimetres of skin should always be excised, and more is often desirable. This may lead in thin women to difficulty or an impossibility of closing the wound. An immediate half-thickness free skin graft on this raw area would often solve the difficulty and probably considerably lessen the chances of a recurrence in the skin. It was Halstead who, in this connexion, said that "the person who made the incision should not have to close it". Instead of the flaps being brought together under tension, he held that they should be pushed back as far as possible, the greatest freedom of the tissues being thus permitted. His idea was thereby to lessen lymphatic stasis in the arm, to eliminate local infested skin lymphatics and to avoid tense keloid scars in which recurrence might appear. Restoration can be either "immediate"—that is, carried out any time within the next seven days by dermatome grafts from the abdomen—or the breast may be restored morphologically by a large coiled tube graft from the loin as suggested by Gillies.

When, however, recurrence has unfortunately become obvious in the skin after a total mastectomy, treatment by radiation is often not very hopeful, and very wide excision and grafting from axilla to sternum would seem to offer the patient the best chance of survival.

In regard to wide and deep excisions for these several types of malignant tumours, the ideal procedure is for the surgeon to excise freely without any thought or consideration for the loss of tissue, but to think only of eradicating and getting beyond the subcutaneous spread of malignant cells and into sound tissues. It is up to the plastic surgeon to make good the loss. It was in the middle of the last war that soldiers began to come back to us with their "tin faces" and wanted "something which they could wash and shave and did

not have to take off at night", and thus stimulated us to the employment of large grafts. During this quarter of a century plastic surgery has not stood still, and it would be difficult indeed for a surgeon now to excise with safety any area of the body which could not be reasonably restored. It is probably better that the excision and the restoration should be done by two different surgeons, otherwise the one who does the excision may (at least subconsciously) be thinking during the operation of the difficulties of restoration and may hesitate to excise as widely as desirable. Apart from this it is surely time plastic surgery was recognized by all other branches of surgery as a special branch, for which special knowledge, training, technique and mentality are necessary in order to be at all certain of results. There is still a tendency to divide the patient's body up on strictly anatomical lines and for a surgeon to say: "Inside this line I do everything including plastic surgery." I venture to suggest that this is sometimes not in the best interest of the patient. After the war is over there will be many young plastic surgeons qualified to make such restorations and it is in their interests that I make this protest. If they are not encouraged to practise their specialty exclusively, they will drift into general practice or general surgery, and I am convinced that for many reasons the two cannot be successfully combined.

ILLUSTRATIVE CASES.

CASE I. Mrs. A., aged sixty-nine years, had a long history of basal celled carcinoma of the left cheek which had been treated by radiation and local excisions, and eventually having become radio-resistant, the whole cheek, outer wall of antrum and lip were excised by Mr. David Whyte. After numerous biopsies had been done to insure that

FIGURE II. Showing extent of tissue loss after excision (Mr. D. Whyte) for basal celled carcinoma.

FIGURE III. Restoration by combined chest and neck tube graft.

removal was complete, she was handed over to me for restoration (Figure II). This was accomplished by means of a long neck tubed flap continuous with a flat flap raised from the chest and double skin grafted underneath—that is, a razor graft was applied to the raw surface of the chest and also to the underside of the flap to form a lining for the mouth and antrum. This was swung up to a prepared bed on the face, and when it was

properly established the neck tube was utilized to form the new lip. The result (Figure III) may be considered to be satisfactory.

CASE II. Mrs. B., aged seventy-two years, and somewhat feeble, had a basal celled carcinoma originally near the inner canthus of the right eye, with a very similar history to Mrs. A. The lesion having become resistant to radiation, she was passed to me. I excised the area freely and replaced the loss with a frontal flap, and for some years everything was satisfactory. Then she came back with a similar lesion at the outer side of the lower eyelid, which had no obvious superficial connexion with the former growth. For various reasons treatment was put off and declined for twelve months. It was then obvious that there was an extension into the orbit and the globe was fixed (Figure IV). Exenteration of the orbit was done, only a small amount of tissue in the posterior portion and some of the upper eyelid being left. The bone of the anterior portion of the orbit immediately under the carcinoma was also removed and the lining of the antrum was exposed. The operation was done under local anæsthesia assisted by

FIGURE IV. Recurrent epidermoid carcinoma of eyelid and orbit.

FIGURE V. Showing dermatome graft of exenterated orbit.

morphine and hyoscine; there was no shock; the temperature and pulse remained perfectly steady. The whole resulting raw area of the orbit and exposed mucous membrane of the antrum was then grafted by a free graft cut with the dermatome from the abdomen (Figure V).

CASE III. Mrs. Q., aged forty-nine years, had a long-standing basal cell carcinoma of the temporal region which had become resistant to radiation and very fixed (Figure VI). The whole area was excised including the pericranium, bare bone being left. As a skin graft will not take on bare bone, the method adopted here was to remove with a very fine chisel the greater part of the outer table of bone, and when the area was covered with sound granulation tissue a dermatome graft was applied (Figure VII).

CASE IV. Mr. R., aged forty-seven years, had an epithelioma of the scalp which was excised down to the bone by Mr. Orgias (Figure VIII). In this case restoration was done by my assistant (C. M. Pickerill) by means of an abdominal tube graft carried up to the head by being attached to the wrist. This makes a very sound replacement which will stand up to any amount of wear and tear if required, and in a man already going bald the additional bare patch is not much noticed (Figure IX). There are four stages in this process and the minimum time is eight weeks.

CASE V. Mr. N., aged fifty-two years, had a typical rodent ulcer of the nose to which he had applied copper sulphate with not very happy results (Figure X). Practically the whole of the left side of the nose was excised with the endotherm knife, which is, I think, whenever it can be used, the safest method of removal. Subsequent

restoration was by means of a lined temporo-frontal flap. This is one of the most viable flaps used in plastic surgery, if care is taken to include the anterior branch of the superficial temporal artery, and if equal care is taken not to wound unnecessarily any veins on the under surface. It has the further advantage of approximating in texture and eventual colour to the rest of the nose (Figure XI).

FIGURE VI. Radio-resistant malignant growth of temporo-frontal region.

FIGURE VII. Dermatome graft after excision of skin, pericranium and outer table of bone.

FIGURE VIII. Excision of scalp for epithelioma (Mr. Orgias).

FIGURE IX. Restoration by tube graft from abdomen via wrist.

CASE VI. Mrs. P., aged fifty-seven years, had a carcinoma of the breast. Some time after radical mastectomy had been done, recurrence occurred in the skin of the chest. She was then passed to me for excision and grafting. An area extending from above the clavicle to the level of the xiphisternum and from the mid-line of the sternum to the axilla was excised with the endotherm knife (Figure XII). Restoration was carried out by means of delayed dermatome grafts from the abdomen. By a delayed graft is meant one which is cut and left attached at one end and replaced in its original situation for ten days or a fortnight. This increases its viability (Figure XIII).

FIGURE X. Excision of outer wall of nose for rodent ulcer (further excision at time of grafting).

FIGURE XI. Restoration of nose by temporo-frontal flap.

FIGURE XII. Excision of chest tissues down to bare ribs and intercostal muscles for recurrent *carcinoma mammæ*.

FIGURE XIII. Area grafted by delayed dermatome grafts from the abdomen.

CASE VII. Mr. B., aged seventy-three years, some two or three years previous to coming under my charge had an epithelioma of the lower lip which was treated by radium. This led to necrosis and a subsequent hiatus in his lower lip (Figure XIV), but there was no sign of recurrence. Restoration in this case was carried out after free excision of the surrounding tissues by a tube graft from the neck, which, by being allowed to hang for at least three weeks, becomes pink in colour and remains so, and hence closely resembles the remainder of the lip when it is in position (Figure XV). An abdominal tube graft remains white however long it is delayed.

The last case brings up an important matter which I have not seen raised before. In the first place, radiologists generally seem to be somewhat afraid of causing necrosis and endeavour to arrange their dosage so that it will destroy the malignant cells without causing necrosis of surrounding structures. Secondly, they appear to be very apologetic when a hiatus from necrosis

FIGURE XIV. Loss of tissue following radiation for epithelioma of lip.

FIGURE XV. Restoration of lip by neck tube graft.

has happened. I suggest that both these mental attitudes are quite wrong. First things first. The first duty of anyone treating a malignant growth is to get rid of it and save the patient's life irrespective of loss of surrounding tissue. The surgeon excises as widely as possible, and I suggest that the radiologist should in many cases not hesitate to act similarly. With all respect, I have often thought that it is the hesitant radiation dose which sets up radio-resistance, leaving behind highly malignant cells. The patient then comes to surgery in a very unsatisfactory condition. Would it not have been better to have purposely employed a full necrosing dose in the beginning (in such cases as would appear to require it) and then to have passed the patient to a plastic surgeon for restoration? Is it not the good hard initial radiation punch which is most often successful? There should be nothing to apologize for in a hiatus; there should be every reason for congratulation. The patient has probably got rid of his trouble for good and his life is safe. I always have biopsies done in these cases and the reports are invariably satisfactory. But there is no cause whatever for congratulation when a growth has become resistant to radiation. We have to ask ourselves which is worse for the patient—a radio-resistant and extending malignant growth or a hiatus. A radiologist must often be in the position of having these two possibilities in

his mind; but if a patient is told beforehand that in order to be certain of getting rid of his particular cancer a hole may result, he will not mind, especially if he knows that the loss can be made good in a satisfactory manner.

SUMMARY.

1. Attention has been directed to the practicability of excision of superficial malignant growths followed by early restoration.

2. Cases illustrating seven different methods of restoration have been described.

3. Attention has been drawn to the desirability of sometimes deliberately producing radiation necrosis.

REFERENCES.

(1) S. Warren and S. O. Hoerr: "Study of Pathologically Verified Epidermoid Carcinoma of Skin", *Surgery, Gynecology and Obstetrics*, December, 1939, page 726.

(2) W. H. Bickel, H. W. Meyerding and A. C. Broders: "Melanoepithelioma (Melanosarcoma, Melanocarcinoma, Malignant Melanoma) of the Extremities", *Surgery, Gynecology and Obstetrics*, Volume lxxvi, May, 1943, page 570.

(3) W. C. White: "Skin Removal in Radical Mastectomy", *Annals of Surgery*, Volume cxv, June, 1942, page 1182, abstracted in *International Abstracts of Surgery*, November, 1942, page 438.

THE SIGNIFICANCE OF HYPOTHENAR ELEVATION IN MOVEMENTS OF OPPOSITION OF THE THUMB.[1]

By SYDNEY SUNDERLAND,
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OPPOSITION is described as that movement in which the pad of the terminal phalanx of the thumb is brought into contact successively with the pads of the remaining digits. It is a complex movement in the examination of which attention is invariably focused on the thenar musculature. The possibility that other muscles may contribute to this movement appears to have escaped notice. The examination of a large series of ulnar nerve lesions has, however, drawn attention to the importance of the intrinsic muscles of the little finger in bringing about contact between that digit and the thumb in opposition. It is with this particular function of the intrinsic musculature of the little finger that this paper is concerned.

Normally the pad of the extended terminal phalanx of the thumb can be readily opposed to the tip of the little finger when that digit is flexed at the metacarpo-phalangeal joint and extended at the interphalangeal joints (see Figure I). If the position adopted is viewed from the palmar aspect, the extent of the translation in a palmar direction of the fifth metacarpal, and to a certain extent that of the fourth also, cannot be fully appreciated. If, however, the dorsum of the hand is kept under observation as opposition is performed, the arching of the heads of the metacarpals brought about by this movement of the fifth and fourth metacarpals in a palmar direction is clearly seen. It is proposed to refer to this movement, which is controlled by the intrinsic muscles of the little finger, as hypothenar elevation.

FIGURE I.

The importance of this elevation in bringing about opposition between the thumb and the little finger is best illustrated by studying the manner in which that movement is impaired when the hypothenar group of muscles is paralysed. Under these conditions considerable difficulty is experienced in executing opposition in the manner outlined above, and on many occasions the thumb fails to reach the little finger. An analysis of this disability demonstrates that failure to establish contact between the digits is due not to any limitation of thenar movement, but to the inability of the little finger and fifth metacarpal to participate for the following reasons:

1. The unopposed action of the long digital extensors consequent on the paralysis of the flexors of the metacarpo-phalangeal joint leads to fixed hyperextension at that joint. In addition, the unopposed action of the long flexors on the interphalangeal joints, consequent on the paralysis of the extensor mechanism, leads to acute flexion at these joints. As a result the digit folds towards the palm in the manner illustrated in Figure II. There is

[1] Accepted for publication on July 16, 1943.

thus no mechanism present for bringing the extended digit forwards in flexion at the metacarpo-phalangeal joint.

2. The abduction of the little finger produced by the unopposed *extensor digiti quinti* increases the distance which the thumb must travel to reach it.

FIGURE II.

3. Paralysis of the hypothenar musculature, and in particular of the *opponens digiti quinti*, prevents that movement of hypothenar elevation which is responsible for lifting the fifth metacarpal, and with it the little finger, towards the thumb. Thus the term opponens becomes appropriate, even in the case of the little finger, for the muscle so named acts to facilitate opposition of the thumb and little finger, in addition to producing that cupping of the hand which to date, I believe, has not been associated directly with the movement of thenar opposition.

A combination of factors, all centred on the intrinsic musculature of the little finger, is therefore responsible for the inability to complete opposition. The thumb attempts to compensate for this loss of movement of the little finger by fully flexing at the terminal phalangeal joint in an attempt to throw the terminal pad still further to the ulnar side in order to reach the little finger (see Figure II).

FIGURE III. Complete lesion of the left ulnar nerve involving the supply to the intrinsic musculature of the little finger. The photograph illustrates the absence of the normal rounded contour of the dorsum of the hand on the affected side when opposition is attempted.

The inability to elevate the hypothenar eminence in these cases results in a characteristic deformity on attempted opposition which is clearly seen when the hand is viewed from the dorsal aspect. This deformity, which is well illustrated in Figure III, is produced by the now unopposed action of the digital extensors which imparts to the dorsum of the hand a flatness that contrasts sharply with the normal arching of the metacarpals on the sound side. This persistent flatness of the dorsum of the hand on attempted opposition, which is seen in ulnar nerve lesions, is such a characteristic and constant sign that it may be used as a rapid and reliable guide to the integrity of the nerve supply to the intrinsic muscles of the little finger.

SUMMARY.

1. Attention has been drawn to the significance of hypothenar elevation in movements of opposition of the thumb and little finger.

2. An additional test for ulnar nerve lesions involving the supply to the hypothenar musculature is described—namely, persistent flatness of the dorsum of the hand on the affected side when opposition of the thumb and little finger is attempted.

ACKNOWLEDGEMENTS.

I wish to express my thanks to the Director-General of Medical Services for permission to publish this paper, and to Mr. L. Preston for the photographs which accompany it.

FLEXION OF THE DISTAL PHALANX OF THE THUMB IN LESIONS OF THE MEDIAN NERVE.[1]

By SYDNEY SUNDERLAND,
Department of Anatomy, University of Melbourne;
115th Australian General Hospital.

FLEXION of the distal phalanx of the thumb, controlled as it is by a single muscle, the *flexor pollicis longus,* which is innervated from one source, may be regarded as an uncomplicated movement. This anatomical feature, together with the ease with which the movement can be voluntarily executed, has endowed it with a certain significance as a rapid and reliable test of injury to the median nerve above the site where the fibres to the muscle leave the trunk. The purpose of this paper is to emphasize the fallibility of this test by recording five cases in which the terminal phalanx of the thumb could still be flexed voluntarily in the absence of a contracting *flexor pollicis longus.*

The following references in the literature to flexion of the terminal phalanx of the thumb in lesions of the median nerve sufficiently illustrate the importance customarily attached to this movement in assessing damage to that nerve.

> Flexion of the thumb phalanges is impossible (Kinnear Wilson, 1940).
>
> The thumb is approached to the forefinger, is extended and lies alongside of it. There is no opposition of the thumb or flexion of the terminal phalanx (Oppenheim, 1911).
>
> When there is complete damage to the nerve . . . the thumb is in persistent extension and adduction (like the thumb of the ape, Figs. 22 and 23, p. 44) and cannot be opposed to the tips of the fingers. The power of flexing the second phalanges on the first is lost . . (Gowers, 1899).
>
> The fingers which cannot be flexed in paralysis of the median are the thumb, the index and the middle finger. . . . The flexion movements of the thumb are completely suppressed (long and short flexors); still, a slight flexion movement of the second phalanx is occasionally possible, by means of the deep head of *flexor pollicis brevis.* . . . Finally, the thumb has lost all its power of flexion and opposition. If the patient is ordered to close his fist it is found that the thumb remains extended and cleaves to the index finger instead of being flexed in opposition in front of the other fingers . . . (Tinel, 1917).
>
> Flexion of the second phalanx of the thumb is impossible, as the *flexor longus pollicis* is paralysed. This can be readily seen by first immobilising the first phalanx (Benisty, 1918).

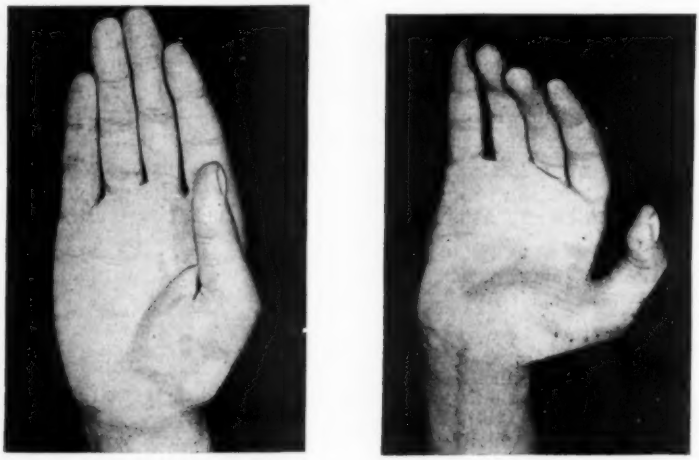
Instances have been recorded, however, in which the patient has retained the ability to flex the terminal phalanx in median nerve lesions in which the long flexor has been paralysed. Both Wood Jones (1919) and Benisty (1918) describe a weak and incomplete passive movement of flexion which is produced by first hyperextending and abducting the thumb and then suddenly relaxing the opponents of the long flexor, which allows the distal phalanx to rebound forwards in flexion. Tinel's reference to this point has already been quoted, though it contains no explanation as to just how the short flexor performs the trick movement attributed to it. The importance of these trick movements in the diagnosis, treatment and prognosis of peripheral nerve injuries requires no emphasis.

The routine examination of 140 peripheral nerve injuries in patients admitted to the 115th Australian General Hospital has to date provided

[1] Accepted for publication on July 16, 1943.

twelve cases in which the *flexor pollicis longus* has been completely paralysed or severed, and in this group are five patients who have retained the ability to flex voluntarily the terminal phalanx of the thumb. The manner in which this movement is executed is of special interest in that the mechanism differs in some details from that operating in those cases already reported, whilst, in addition, the trick flexion is of fair range and well sustained.

In the series of twelve cases referred to the muscle was completely paralysed in nine and its tendon severed in three. Two of the former group may be excluded from further consideration because of an associated lesion of the dorsal interosseous nerve which resulted in a paralysis of those muscles upon which the execution of the trick movement to be described depends. Thus the ability to execute trick flexion was present in five out of ten cases



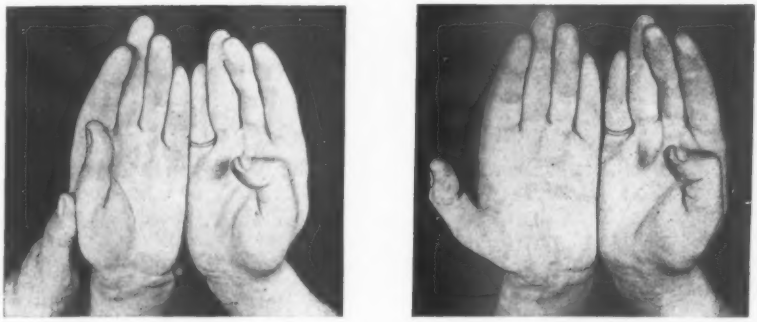
(*a*) (*b*)

FIGURE I. *Flexor pollicis longus* paralysed. (*a*) Flexion of the terminal phalanx of the thumb is here being attempted voluntarily, but with the thumb lying in the position shown no movement occurs. (*b*) This illustration demonstrates the manner in which the hand is postured in order to bring about flexion of the terminal phalanx of the thumb.

in which conditions for its development were favourable. In four out of these five cases the muscle was completely paralysed, whilst in the fifth the tendon had been severed and later sutured. It is interesting to note that in the three cases in which the tendon had been divided the trick movement appeared only in that case in which the tendon had been repaired.

The manner in which the trick movement of flexion is executed in those cases in which the muscle is paralysed is well illustrated in Figure I. On attempting to flex voluntarily the terminal phalanx of the thumb the wrist is first hyperextended and the thumb fully radially abducted. The tendon of the paralysed long flexor is thereby stretched as it passes along the volar surface of the thumb and the terminal joint consequently flexes. This trick movement can be readily unmasked by asking the patient to flex the terminal phalanx when the thumb is held adducted to or inside the radial margin of the index finger with the wrist in the neutral position. The action of the *abductor pollicis longus* and the extensors of the wrist is thereby neutralized and the tendon of the paralysed *flexor pollicis longus* relaxed. Flexion of the terminal joint is then no longer possible.

In that case in which the tendon had been divided and sutured, the patient retained the ability to flex the distal phalanx of the thumb powerfully, through almost a full range as may be seen from reference to Figure II. Close inspection, however, revealed that the trick movement already described was responsible for this flexion. When the thumb was held adducted inside the radial margin of the index finger, not even a trace of flexion could be



(*a*) (*b*)

FIGURE II. The tendon of the *flexor pollicis longus* has been divided and sutured. (*a*) This illustration demonstrates the inability to flex voluntarily the terminal phalanx of the thumb when that digit is held inside the radial margin of the index finger. (*b*) This photograph illustrates the wide range of flexion which may be obtained by trick action when the thumb is free to move.

obtained. Incidentally, when flexion was attempted the thumb had to be forcibly held in this position, for when released it immediately sprang into the position illustrated. Though sutured, the *flexor pollicis longus,* whose nerve supply had apparently not been involved, could not actively shorten owing to adhesions to produce the desired result, and the trick movement was therefore resorted to in order to compensate for this loss.

CONCLUSIONS.

The facility with which flexion of the distal phalanx of the thumb may be executed when the *flexor pollicis* is completely paralysed demands a reconsideration of the value of this test as an infallible clinical guide to the functional integrity of the median nerve. If flexion at the terminal joint of the thumb is to be utilized as a guide in assessing damage to, and recovery in, the median nerve, then care should be taken to see that the thumb is held inside the plane of the index finger before flexion is attempted.

ACKNOWLEDGEMENTS.

I wish to express my thanks to the Director-General of Medical Services for permission to publish this paper, and to Mr. L. Preston for the photographs which accompany it.

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VOLUNTARY MOVEMENTS AND THE DECEPTIVE ACTION OF MUSCLES IN PERIPHERAL NERVE LESIONS.[1]

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In the diagnosis and treatment of peripheral nerve lesions one relies in considerable measure on the state of the muscles innervated by the injured nerve for information concerning both the extent of the lesion and the progress of regeneration. Information from this source may be obtained in several ways, only one of which will be considered in this paper—namely, the examination of voluntary movements. By this method the paresis or paralysis of any particular muscle or muscles is assessed in terms of derangement of movement. Obviously, then, when carrying out the relevant tests, every factor which may in any way mislead the observer as to the severity of the lesion or the progress of regeneration must be recognized and duly accounted for. Among the factors requiring immediate recognition in this respect are certain voluntary movements which can still be effectively carried out, even when those muscles customarily held to be responsible for their execution have been deprived of their nerve supply. Because of the manner in which these movements make their appearance they are variously referred to as trick, supplementary or deceptive movements. It is with the *modus operandi* of these trick movements that this paper is concerned.

Apart from references by Duchenne (1867) and by Beevor (1903) to deceptive muscle action in their accounts of muscular movements, interest in this subject dates from the time of the Great War, 1914-1918, when valuable studies were made by Wood Jones (1919) in England, by Pollock (1919) in the United States, and by Tinel (1917), Benisty (1918) and other workers in various French neurological centres. With the cessation of hostilities, however, and the subsequent dispersal of the clinical material on which the investigations had been based, interest in the subject appears to have lapsed. This reaction may perhaps account for the fact that, despite the wealth of information made available, the question of deceptive movements did not receive the widespread and permanent recognition which the importance of the subject merited. Thus this important and practical aspect of muscle function is neglected in textbooks of anatomy, while references to disturbances of movements in articles on peripheral nerve injuries appearing during the interval between the two Great Wars provide many examples illustrating what little impression the newly acquired information had made on current ideas concerning muscular movements. Two publications, "The Principles of Anatomy as Seen in the Hand" (Wood Jones, 1941) and "Muscle Function" (Wright, 1928), are, however, notable exceptions in this respect. The books by Stookey and Foerster on peripheral nerve injuries have not been available for reference, so that it has not been possible to ascertain whether these authors devoted any attention to this subject.

With the reappearance of peripheral nerve injuries in ever increasing numbers, attention has again been focused on muscle action, and trick movements have returned from obscurity to assume a role of considerable import-

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ance in the diagnosis and treatment of peripheral nerve injuries. In current articles, however, it is customary to find only a very brief reference, if any, to these movements; these are often incorrectly described and only on rare occasions is there any mention of the original investigations for those anxious to obtain further information on the subject. Thus two recent papers (L. J. Pollock, 1941; Supplement on War Medicine and Surgery in *The Medical Journal of Australia*) contain the statement that flexion of the terminal phalanx and extension of the metacarpo-phalangeal joint of the thumb are two movements which cannot be supplemented in complete lesions of the median and radial nerves respectively. Experience has shown that these are two movements which are very frequently compensated for in the nerve lesions quoted. Furthermore, a study of the clinical histories of peripheral nerve injuries among patients admitted to a base hospital in this country indicates that many of those responsible for the early care and recording of these lesions are quite unaware that such anomalous movements and muscle actions exist. This is a matter for considerable concern, since the failure to recognize the nature of these movements will invariably lead to false estimates of nerve injury and regeneration. This will, in turn, result in incorrect diagnoses and in unjustified optimism concerning either the progress of spontaneous regeneration or the efficacy of a surgical procedure designed and undertaken to facilitate regeneration.

It is hoped in this communication to remedy this defect by outlining the genesis, range and effects of trick movements. The observations which form the subject of this paper were made on 170 cases of peripheral nerve injuries which have been admitted to an Australian general hospital since September, 1941, and which have been under regular observation by the author since that time. Every trick movement described in this report has been personally observed, recorded and demonstrated.

MUSCLES AND MOVEMENTS.

It is now well recognized that the execution of even the simplest voluntary movements is a complex process involving the delicately coordinated action of many muscles not necessarily supplied by the same peripheral nerve. Thus certain muscles, the prime movers, are delegated to produce the movement initiated from the motor cortex, some contract synergically to prevent the undesired actions of the prime movers, while others act as antagonists and fixators to give refinement, steadiness and precision to the movement. Moreover, the coordination between these various units is such that the absence of one is sufficient to impair or disorganize the action of the others and the efficiency of the movement consequently suffers. It is therefore of the greatest importance to know not only what muscles are normally involved in any particular movement, but also the role assigned in that movement to each individual muscle. Only if the examiner possesses an intimate knowledge of the details of the physiology of movement, will the testing of voluntary movements become a reliable procedure and will it provide the maximum information.

In connexion with the actual application of the tests the following points are worthy of consideration:

1. The only infallible guide to the integrity of a muscle is to see and feel it contract. The application of this test is, unfortunately, limited by the anatomical position of the muscle, for only those directly accessible to palpation and observation can be examined in this manner. Moreover, when this method is employed great care must be taken not to confuse for active contraction of the muscle being examined the displacement or distortion of a muscle, which may be caused by the contraction of neighbouring muscles or by the pull imparted by fascial attachments.

2. The inability to execute a movement voluntarily, provided restriction of joint action and shortening of the antagonists can be excluded, usually indicates involvement of the prime movers. However, in this connexion it is important to remember that, though a muscle may be unable to execute a voluntary movement, it may be capable of sufficient contraction to maintain the part in a position into which it has been moved passively. Thus it is a matter of frequent observation that a *tibialis anterior* which is not capable of producing even a flicker of dorsiflexion of the foot, can nevertheless hold the foot in a dorsiflexed position against gravity when it has been placed in that position. This feature is frequently overlooked, but it is of considerable importance since it is often the first sign of recovery.

3. Though an individual muscle may by virtue of its attachments, the direction of its fibres, and the design of the joint surfaces over which it passes, perform a variety of actions as a prime mover, the effect of its contraction in the normal state is finally determined by the function of the other muscles in the movement pattern. If any of these units are paresed or paralysed, then the movement is no longer correctly executed, and the manner in which it is impaired will often indicate the basis of the disability. For example, when all three carpal extensors contract pure extension of the hand results, the ulnar adductor action of the ulnar extensor being cancelled by the radial abductor action of the radial extensors. If the *extensor carpi ulnaris* is not contracting, then voluntary extension at the wrist is accompanied by radial deviation of the hand since the abducting action of the radial extensors is now unopposed. This radial deviation or abduction diminishes as the *extensor carpi ulnaris* recovers. Thus deformities developing during movement can give valuable information concerning the paresis or paralysis of muscles.

4. The development of a deformity at rest, due to the unopposed action of antagonists, always provides information concerning the state of the prime movers. The classical ulnar *griffe* so familiar to all develops as a result of involvement of the ulnar-supplied intrinsic musculature of the hand.

5. The ability to execute a movement voluntarily cannot be accepted as infallible proof that the prime movers normally responsible for producing it are functioning. This introduces the question of trick movements and the trick actions of muscles.

Trick movements obviously, from the accepted definition, make their appearance only when the normal prime movers are involved; consequently when they are recognized they afford reliable evidence concerning involvement of the prime movers. If, on the other hand, they escape detection, false estimates concerning the extent of the lesion will invariably result. These trick movements may be brought about in the following ways:

1. By the trick action of a muscle. This involves the active contraction of a muscle which is favourably placed to compensate for the prime movers, but which when the latter are functioning normally is not called into action. For example, when the carpal flexors are paralysed the hand can still be flexed by the trick or supplementary action of the *abductor pollicis longus*.

2. By the contraction of an intact muscle which, by virtue of an accessory slip of insertion into the tendon of the paralysed muscle, can exert a pull on that tendon and thereby supplement for the action of the paralysed muscle. Such an example is provided by the *abductor pollicis brevis* and the slip which this muscle sends to the *extensor pollicis longus*. Thus in cases in which the *extensor pollicis longus* is paralysed the terminal phalanx of the thumb can still be extended by the *abductor pollicis brevis*.

3. By the tendon action of the paralysed prime mover which is brought into action by the contraction of the appropriate antagonists.

There are muscles which, by virtue of their attachments, can move two segments of a limb in one direction (see Figure I). An example of such "two-joint" muscles, as they have been called (Lombard, 1903), is provided by the long flexors of the fingers which flex the fingers and by their overaction flex the wrist. Both movements carry the hand and digits in a palmar direction. The length of such a "two-joint" muscle at rest, however, is usually insufficient to permit a full range of movement in the opposite direction at both the joints over which it passes [see Figure I, (ii)]. Consequently in the system outlined full extension of the wrist and fingers cannot usually be executed simultaneously on account of the limited length of the long digital flexors, whilst full flexion of both the wrist and fingers is not possible owing to the limited length of the *extensor digitorum communis*. Furthermore, in such a "two-joint" system movement at the proximal of the two joints, in a direction opposite to that executed by the "two-joint" muscle, will lead to a tightening of the latter so that the muscle will pull upon the distal segment to which it is attached and bend it at the distal joint [see Figure I (iii)]. For instance, if the wrist is fully extended, the long digital flexors are tightened and pull the fingers into mild flexion at the interphalangeal joints. The action of a "two-joint" muscle introduced in this manner is referred to as its tendon action (Lombard, 1903), and since it does not involve the active contraction of the muscle, it can operate when the muscle is denervated. Thus when the long flexors of the fingers are paralysed a variable degree of trick flexion can be obtained at the interphalangeal joints by hyperextending at the wrist.

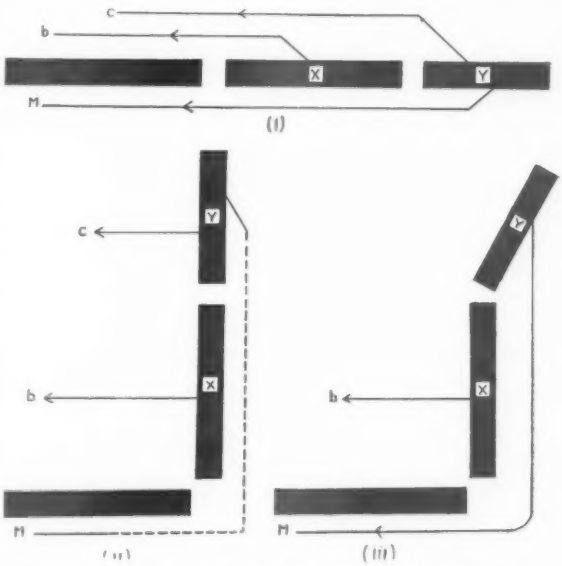


FIGURE I. Diagram illustrating the tendon action of a "two-joint" muscle M. (i) The muscle M can by its contraction flex both segments X and Y downwards. The muscles b and c can by their contraction extend both segments upwards. (ii) Full extension of both X and Y, as illustrated, is not possible owing to the limited length of M. (iii) If X is fully extended, M is tightened and Y is passively pulled into flexion. This action of M is referred to as its "tendon action".

4. By first strongly contracting the antagonists and then suddenly relaxing them. This permits the segment displaced to rebound in the opposite direction, which results in a movement simulating the action of the paralysed prime mover. Thus in complete lesions of the lateral popliteal nerve pseudo-dorsiflexion of the toes may be obtained by strongly contracting the plantar flexors of the toes and then suddenly relaxing them, which permits the toes to rebound upwards in dorsiflexion.

5. By a muscle obtaining an anomalous insertion and/or nerve supply. Classical examples are provided by the variation in insertion of the third

lumbrical muscle and the variation in nerve supply of the *flexor digitorum profundus* and thenar muscles.

6. By the action of gravity. It is not proposed to give any further consideration to this factor since it is a cardinal rule when testing voluntary movements always to eliminate the influence of gravity. Failure to do this is only inviting error.

Testing against resistance will often expose a trick movement by eliminating tendon action and gravity. Such a test does not, however, always enable one to discriminate reliably between a trick movement and the movement produced by either a muscle previously paralysed but showing recovery or a muscle originally very severely paresed. In the latter cases the involved muscle may be quite capable of effecting a restricted range of movement, but not against resistance. Any test which relies on movement against resistance, is no guide to the very first signs of recovery. Consequently other measures must be adopted to differentiate between the movement due to a severely paresed or recovering muscle and that due to trick movement. This point has not been made clear in a recent publication (Medical Research Council of Great Britain War Memorandum Number 7, 1942), where movements are shown being tested against resistance. This is misleading, for if such a policy is followed then, in many cases, the earliest signs of regeneration will be missed.

Sufficient has now been written to indicate, in general terms, the care which must be exercised in testing voluntary movements and in evaluating the information thereby obtained. The testing of voluntary movements is admittedly a difficult and painstaking procedure, but if full advantage is taken of the many opportunities presented by this method for assessing muscle function, the results will amply repay the effort expended.

LESIONS OF THE BRACHIAL PLEXUS.

Excluding the shoulder girdle, the effects of plexus lesions on voluntary movements may be expressed in terms of lesions of the peripheral nerve trunks. Consequently consideration of trick movements appearing distal to the shoulder in plexus lesions can be conveniently covered in subsequent sections. Discussion will here be limited to abduction of the arm.

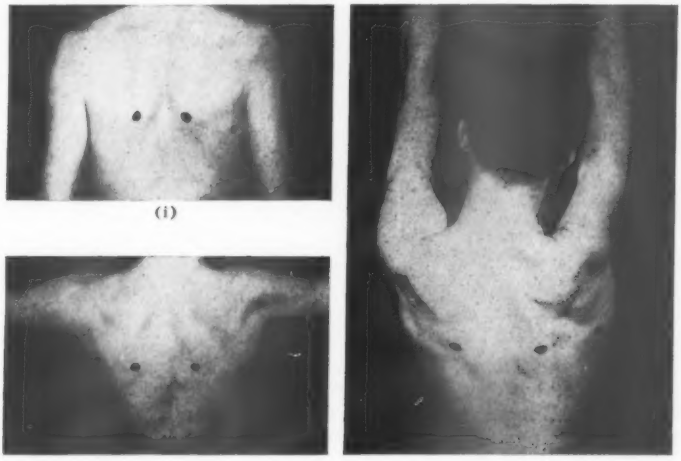
Paralysis of the Deltoid and Supraspinatus.—Paralysis of the deltoid and supraspinatus is frequently said to result in an inability to abduct the arm (Tinel, 1917; Benisty, 1918). In this series three patients with paralysis of these muscles have retained the ability to abduct the arm actively through 45° with only a trace of forward flexion. The movement in each is executed by fixing the head of the humerus in relationship to the glenoid fossa, presumably by the biceps and coraco-brachialis, while the trapezius externally rotates the scapula and carries the arm away from the side. This trick movement is detected by keeping the inferior angle of the scapula under observation and by palpating the trapezius, supraspinatus and deltoid during the movement. It has not been possible to ascertain if the *serratus anterior* contributes to this abduction, as palpation of the muscle, which is a very difficult procedure even under favourable conditions, did not provide any positive information in these patients. A case in which the deltoid, supraspinatus and *serratus anterior* have all been paralysed has not yet appeared to settle this question conclusively.

Paralysis of the Trapezius.—It is generally accepted that a full range of abduction can usually be carried out in paralysis of the trapezius. At rest the now unopposed rotatory action of the deltoid and the weight of the dependent arm produce internal rotation of the scapula. When abduction is

attempted the deformity is increased as the inferior angle of the scapula swings in towards the mid-line. However, as the range of abduction increases, the point at which the action of the *serratus anterior* is introduced is ultimately reached. The deformity is then corrected and abduction proceeds to completion.

Paralysis of the Serratus Anterior.—The disability in paralysis of the *serratus anterior* is too well known to require other than a brief reference. There is no deformity at rest. Abduction can be executed through approximately 90°, but beyond this point no further movement is possible owing to the absence of the external rotatory action of the paralysed muscle on the scapula. Both abduction and forward flexion are accompanied by marked winging of the scapula, since the serratus is unable to maintain the scapula in contact with the thoracic wall. This winging on movement far exceeds the deformity at rest seen in cases of trapezius paralysis.

Paralysis of the Serratus Anterior and Trapezius.—One case only has been observed in which the *serratus anterior* is severely paresed and the inferior half of the trapezius paralysed. The arm can be abducted 50° from the side by the deltoid and supraspinatus, but the movement requires considerable effort, is unstable, and is accompanied by marked winging and



(i) (ii) (iii)

FIGURE II. Paralysis of the right deltoid and *teres minor*. (i) The three dark spots on the right side represent, from medial to lateral, the positions of the inferior angle of the scapula with the arm (*a*) at the side, (*b*) abducted through 90° and (*c*) abducted to the vertical. (ii) Arms abducted through 90°. Marked external rotation of the right scapula so that the inferior angle has moved laterally and is now situated beneath the middle spot. The left scapula has undergone only a trace of external rotation. (iii) Arms abducted to the vertical position. Further rotation of both scapulæ, but the degree of rotation on the right exceeds that present on the left.

internal rotation of the scapula. Brunnstrom (1941) has also commented on the serious disability caused by paralysis of both the trapezius and *serratus anterior*. Abduction in his case was limited to approximately 60°.

Isolated Paralysis of the Deltoid and of the Supraspinatus.—Duchenne (1867) concluded from observations on cases of complete atrophy of the deltoid that the supraspinatus alone is capable of fully abducting the arm to the horizontal. Forrester-Brown's (1920) observations on peripheral nerve

injuries led to the same conclusion. Tinel (1917), on the contrary, contends that

> substitutionary movements scarcely exist at all in the case of the deltoid. The supraspinatus alone is capable of slightly raising the arm outwards and forwards, with rotation inwards; this movement is extremely feeble, and is incapable of introducing any effective substitution for paralysis of the deltoid.

According to Stewart and Evans (1916), paralysis of the deltoid results in an inability to abduct the arm. The importance of the supraspinatus in shoulder abduction has been emphasized by Watson-Jones (1938), and his conclusions, based on a study of the effects of complete rupture of the tendon of this muscle, may be quoted:

> The humerus cannot be abducted by the deltoid alone, however powerful it may be, the supraspinatus is an essential synergist. . . . If the supraspinatus is inactive strong contraction of the deltoid pushes the head of the humerus up towards the acromion and holds it there while the scapula rotates. Weak abduction to about 60 degrees is possible through scapula movement, but there is no true gleno humeral abduction.

One patient (see Figure II) has been investigated in whom the deltoid and *teres minor* are the only muscles paralysed. He can freely abduct the arm to 90° with only a trace of forward flexion. Rotation of the scapula occurs throughout this movement and appears to be responsible for effecting most of the abduction. Examination of the sound limb during abduction to 90° reveals that on that side very little rotation of the scapula takes place. From this position the involved arm can be elevated almost to the vertical, the only residual defect being slight forward flexion in the final position. This elevation is accompanied by still further rotation of the scapula, the inferior angle of which, with both arms vertical, is displaced further laterally than that on the sound side. This case demonstrates conclusively that even when the deltoid is completely paralysed it is possible for the patient to abduct the arm fully and then to elevate it with only a very slight simultaneous forward displacement. No case in which the supraspinatus alone has been paralysed, has been examined.

COMPLETE LESIONS OF THE RADIAL NERVE.

Every movement normally controlled exclusively by the radial nerve may be preserved in complete lesions of this nerve.

Extension of the Elbow.—This movement can always be executed, but not against resistance, by the action of gravity. The lesion can be correctly assessed only by taking care to eliminate this factor when testing the movement and by palpating the heads of the muscle on attempted extension.

Supination of the Forearm.—The biceps is not involved in these lesions and continues to supinate the forearm. Duchenne (1867), Tinel (1917), Benisty (1918), Pollock (1919) and Mackenzie (1940) contend that the supinating action of this muscle cannot be dissociated from its action as a flexor of the forearm and that efforts to supinate the forearm will inevitably result in a combined movement of flexion and supination. My observations confirm those of Beevor (1903), Woods (1919) and Wright (1928), who have demonstrated that if the triceps is paralysed the forearm is flexed simultaneously, but that if this muscle is intact the flexor action of the biceps can be prevented by its synergic contraction. If the biceps and supinators are paralysed, the patient resorts to external rotation of the arm at the shoulder joint to bring about limited supination of the hand (see also Benisty, 1918).

Extension of the Wrist.—It is a common observation that some extension at the wrist is often retained in complete lesions of the radial nerve (see also Duchenne, 1867; Beevor, 1903; Tinel, 1917; Pollock, 1919; Wood Jones, 1919; Woods, 1919; Forrester-Brown, 1920). This is produced by the tendon

action of the *extensor communis* which is brought into action by fully flexing the fingers at the metacarpo-phalangeal joints (see Figure III). In this way the *extensor communis* is tightened and pulls the hand into extension. This trick action can be unmasked by requesting the patient to extend the fingers and wrist simultaneously and by palpating the carpal extensors. Trick extension will naturally not make its appearance if contractures and periarticular adhesions prevent flexion at the metacarpo-phalangeal joints or free movement at the wrist joint.

Pollock (1919) has described two forms of trick extension of the hand which have not been seen in this series. In one, strong contraction of the *pronator teres* is said to be responsible, the extension being due to "first, lengthening of the extensor tendons and muscles, and, second, to a leverage exerted on the scaphoid by the head of the radius". However, the accompanying illustration which he provides, shows almost full flexion at the metacarpo-phalangeal joints, and it would appear that this, rather than the mechanism outlined, would be more likely to have caused the extension. In the other

there is seen strong adduction and opposition of the thumb against the proximal phalanx of the index finger. At the same time resistance to this action is made by the contraction of the lumbricale muscle, and the hand is extended on the forearm to a noticeable degree. During this action the middle, ring and little fingers show flexion at the proximal phalanx and extension of the two distal phalanges.

FIGURE III. Complete lesion of the left radial nerve. Extension of the wrist produced by flexion of the metacarpo-phalangeal joints which introduces the tendon action of the *extensor digitorum communis*.

It is difficult to see, however, how leverage produced by muscles whose attachments and actions are located entirely distal to the wrist joint can influence that joint. A more likely explanation to account for the extension obtained is that it is again produced by the flexion which takes place simultaneously at the metacarpo-phalangeal joints.

Extension of the Fingers.—Extension at the interphalangeal joints is not disturbed in radial nerve lesions since this movement is performed by the lumbricals and interossei. Often in these cases the fingers are held extended at the metacarpo-phalangeal joints owing to splinting and shortening of the long extensors. From such a position the fingers can be fully straightened by the extensor action of the lumbricals and interossei on the interphalangeal joints, and this may give an erroneous impression that the *extensor digitorum communis* is contracting.

The fingers can be extended at the metacarpo-phalangeal joints by the tendon action of the *extensor digitorum communis* which is introduced by fully flexing the wrist (see also Duchenne, 1867; Beevor, 1903; Tinel, 1917; Pollock, 1919; Woods, 1919; Forrester-Brown, 1920; and Wright, 1928). In this way the muscle is tightened and pulls the fingers into extension at the metacarpo-phalangeal joints (see Figure IV). To accomplish the trick action a full and free range of wrist flexion is necessary. If, however, the wrist is fixed to prevent flexion, any extension of the digits at the metacarpo-phalangeal joints can be attributed to the action of the *extensor communis*.

Confirmatory evidence of this action can be obtained by palpating the muscle during the test.

Extension of the Terminal Phalanx of the Thumb.—Trick extension of the thumb produced by expansions which the intrinsic thenar muscles send to the *extensor pollicis longus* has been described by Sabatier, Bouvier, Duchenne (1867), Beevor (1903), Benisty (1918), Wood Jones (1919), Pollock (1919), Woods (1919), Forrester-Brown (1920) and Wright (1928). In this series there were 29 patients with a complete lesion of the radial or of the dorsal interosseous nerve, and of these, 25 retained the ability to extend the terminal phalanx of the thumb. The high incidence of such a trick movement is important in view of the statements by Tinel (1917) and Pollock (1941) that this movement cannot be supplemented in radial nerve lesions, though in an earlier paper Pollock (1919) described trick extension.

FIGURE IV. Complete lesion of the left radial nerve. Extension of the fingers at the metacarpo-phalangeal joints produced by fully flexing the wrist.

The trick movement in this series has been executed by the slip from the *abductor pollicis brevis* which passes round the radial margin of the thumb to blend with the long extensor tendon. Extension of the distal phalanx is therefore necessarily accompanied by palmar abduction, which in addition tightens the *extensor pollicis longus* and thereby introduces its tendon action (see Figure V). This trick action will also extend simultaneously the proximal phalanx of the thumb. In one case, however, the patient retained the ability to extend the distal phalanx without palmar abducting the thumb (see Figure VI). If the thumb is held immobilized in full radial abduction, the unopposed long flexor is tightened and the distal phalanx moves into flexion, from which position the patient is usually unable to extend it though strenuous efforts are made to pull the thumb into palmar abduction. In some cases the thumb can be extended even in this position, but the efforts of the *abductor pollicis brevis* cannot escape detection. Thus by immobilizing the thumb in this manner the trick action of the *abductor*

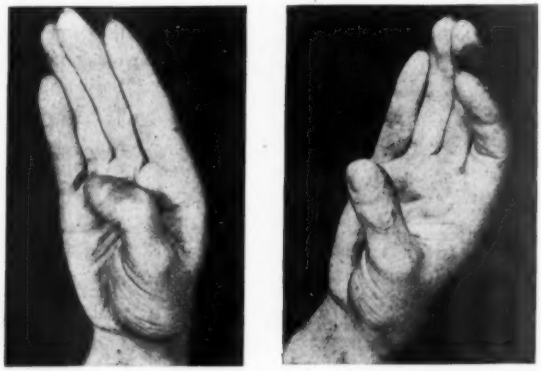


FIGURE V. Complete lesion of the right radial nerve. Extension of the terminal phalanx of the thumb by the slip passing from the *abductor pollicis brevis* to the *extensor pollicis longus*. Observe that extension of the phalanx is here accompanied by palmar abduction of the thumb.

pollicis brevis and its slip can be unmasked. Trick extension may also be produced by first flexing the distal phalanx and then suddenly relaxing the *flexor pollicis longus* which allows the phalanx to rebound backwards (see also Wood Jones, 1919; Pollock, 1919). Finally, moving the thumb in a palmar or ulnar direction will pull on and tighten the paralysed extensors and in this way a movement of extension is imparted to the distal phalanx (see also Wood Jones, 1919).

Radial Abduction of the Thumb.—Radial abduction in the plane of the palm is normally carried out by the *abductor pollicis longus* and *extensor pollicis brevis*. Trick radial abduction of the thumb has been observed in two cases of complete lesions in which regeneration had advanced only as far as the *extensor carpi ulnaris*. In these cases the normal movement was simulated by fully ulnar-deviating the hand with the *flexor* and *extensor carpi ulnaris* and thereby increasing the distance between the thumb and the radial margin of the hand. This supplementary action, however, is a poor substitute and should never confuse the careful observer. Normally in performing radial abduction of the thumb the *flexor* and *extensor carpi ulnaris* act synergically to prevent the radial-deviating action on the hand of the long abductor and extensor of the thumb. In the cases recorded efforts to abduct the thumb radially presumably called for contraction of the synergists, and these, acting in the absence of their opponents, ulnar-deviated the hand and in this way widened the interval between the thumb and hand.

FIGURE VI. Complete division of the left radial nerve. Extension of the terminal phalanx of the thumb, presumably by means of a slip passing to the long extensor tendon from the intrinsic muscles. Observe that in this case the extension is not accompanied by palmar abduction of the thumb. Contrast with the trick extension illustrated in Figure V.

COMPLETE LESIONS OF THE MEDIAN NERVE.

Pronation of the Forearm.—Two patients with complete lesions of the median and ulnar nerves in the upper arm have been examined in whom a very clumsy, but definite, movement of pronation was executed from full supination by the brachio-radialis. With the elbow fixed at the side to eliminate any possibility of internal rotation at the shoulder, the patient, after a vigorous and concentrated effort, swung the forearm and hand into a position from which gravity could act to complete pronation. The movement was a clumsy and disorganized one, but on occasion it would appear that the brachio-radialis is capable of placing the forearm in a position from which gravity can act to complete pronation. Woods (1919) and Forrester-Brown (1920) have reported similar cases. Benisty (1918) believes that pronation from the fully supinated position in these cases is aided by the *extensor carpi ulnaris* and *extensor digitorum communis*. In testing for movements of pronation care should also be taken to fix the elbow by the side in order to eliminate the pronating effect of internal rotation at the shoulder (see also Benisty, 1918; Pollock, 1919). The most reliable information concerning

pronator teres function is obtained by palpating the muscle during pronation. This test cannot be applied to the *pronator quadratus*.

Flexion of the Wrist.—Flexion of the wrist can still be carried out by the *flexor carpi ulnaris*, but the movement is frequently, though not always, accompanied by ulnar deviation (see Figure VII). Palpation of the *flexor carpi radialis* and examination of its tendon on forced flexion will give the required information.

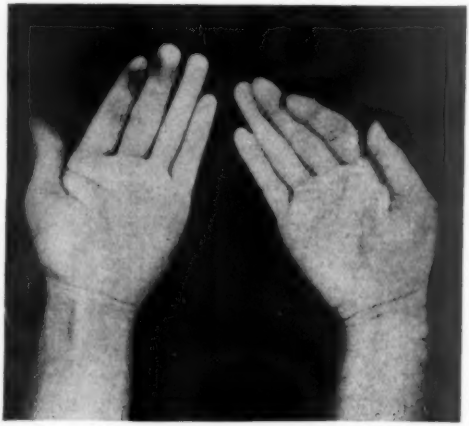
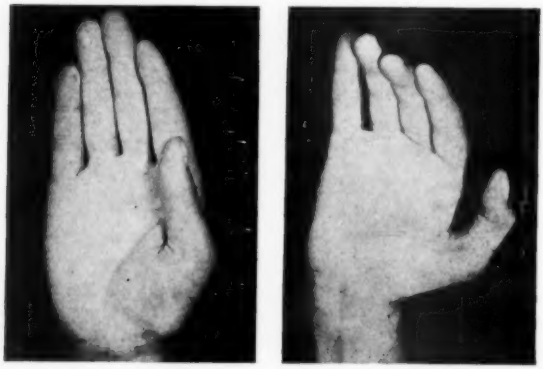


FIGURE VII. Partial lesion of the right median nerve. Severe paresis of the *flexor carpi radialis*. Observe the marked degree of ulnar deviation which accompanies flexion of the wrist. Photograph taken over the patient's right shoulder.

Flexion of the Terminal Phalanx of the Thumb.—Benisty (1918), Wood Jones (1919) and Pollock (1919) have described a weak and incomplete passive movement of trick flexion which is produced by first hyperextending and abducting the thumb and then suddenly relaxing the opponents of the long flexor which allows the distal phalanx to rebound forwards in flexion. Tinel (1917) also refers to trick flexion when he writes that "a slight flexion movement of the second phalanx is occasionally possible by means of the deep head of *flexor pollicis brevis* . . .", but no explanation is given as to just how the short flexor performs the trick movement attributed to it.



(*a*) (*b*)

FIGURE VIII. Complete lesion of the right median nerve. *Flexor pollicis longus* paralysed. (*a*) Flexion of the terminal phalanx of the thumb is here being attempted voluntarily, but with the thumb lying in the position shown no movement occurs. (*b*) This illustration demonstrates the manner in which the hand is postured in order to bring about trick flexion of the terminal phalanx of the thumb.

In a previous report (Sunderland, 1944) five cases have been described in which the terminal phalanx of the thumb could still be flexed voluntarily in the absence of a contracting *flexor pollicis longus*. The manner in which this movement is executed is of special interest in that the mechanism varies in some details from that operating in those cases already reported by Wood Jones, Benisty and Pollock, whilst, in addition, the trick flexion is of fair range and well sustained. In executing this movement the wrist is first hyperextended and the thumb fully radially abducted (see Figure VIII). The tendon of the paralysed long flexor is thereby tightened as it passes along the volar surface of the thumb and the terminal joint consequently flexes.

This trick movement can be readily unmasked by asking the patient to flex the terminal phalanx when the thumb is held adducted inside the radial margin of the index finger with the wrist in the neutral position. The effect of the *abductor pollicis longus* and the extensors of the wrist is thereby neutralized and the tendon of the paralysed *flexor pollicis longus* relaxed. Flexion of the terminal phalanx is then no longer possible. The ability to execute this trick flexion was retained in five out of ten cases in which conditions necessary for its development were present. The literature abounds with references emphasizing the suppression of flexion of the distal phalanx of the thumb in complete lesions of the median nerve, and for this reason the observations recorded above are of especial significance.

Thus when utilizing this movement for estimating median nerve recovery, care should be taken to see that the thumb is in such a position that all possibility of the trick movement operating is eliminated.

Palmar Abduction of the Thumb.—Palmar abduction should normally be tested in a plane at right angles to the palm and inside the radial margin of the hand and index finger. Under these conditions the movement is produced by the *abductor pollicis brevis, flexor pollicis brevis* and the opponens, whilst the action of the *abductor pollicis longus,* which abducts the thumb outside the test plane, is minimized or completely neutralized. If the intrinsic thenar muscles indicated are paralysed, true palmar abduction is lost (see also Beevor, 1903; Highet, 1943).

On occasion the *abductor pollicis longus* can impart a few degrees of true palmar abduction to the metacarpal (see also Wood Jones, 1919), but efforts to increase the range immediately result in radial abduction of the thumb. It has not been possible to confirm Forrester-Brown's (1920) observation that the *abductor pollicis longus* and opponens, acting together, can exactly imitate the action of the *abductor brevis.* The extent to which palmar abduction is retained in complete lesions of the median nerve is principally dependent on:

1. The size of the head of the *flexor pollicis brevis* supplied by the ulnar nerve. The attachments of this slip are such that, if it is of any significant size, it is capable of producing a limited range of palmar abduction and internal rotation. This range may be improved by hypertrophy of fibres following paralysis of the median-supplied thenar muscles.
2. An anomalous or double innervation of the *abductor pollicis brevis,* the superficial head of the *flexor pollicis brevis* or the opponens which are normally supplied exclusively by the median nerve. The anomalous or additional supply may come from the ulnar (Brooks, 1886; Cannieu; Froment; Flemming, 1887; Highet, 1943), musculo-cutaneous (Foerster, 1929) or radial (Stookey; Vogt; Kasper; Etzold; Lejars) nerves.

Though the number of cases in which these muscles escape and the relevant movements are retained is not great, the possible participation of such deceptive movements should always be taken into consideration when assessing thenar function. Highet (1943) has reported as follows on the disturbance of thenar movements in twenty cases of complete median lesions:

> *Flexor pollicis brevis* was active in 16 cases and inactive in 4. In 4 cases there was certainly some action in *opponens pollicis,* in addition to *flexor brevis.* In 2 cases there was some action in *abductor pollicis brevis,* in addition to action in *flexor brevis* and opponens. In one of these cases there was no paralysis or wasting of any of the thenar muscles (fig. 3), but in the other case *abductor brevis,* though certainly active, was slightly wasted. In several of these 20 cases the opportunity was taken to stimulate the ulnar nerve exposed at operation. Ulnar stimulation produced a contraction in the paralysed thenar muscles.

In the author's series there are eight complete lesions of the median nerve. In two of these the *abductor pollicis brevis* escaped and the opponens was severely paresed. The existence of such anomalous innervations can be

confirmed or excluded by blocking the nerve believed to be responsible with 2% procaine solution.

Opposition of the Thumb.—Opposition is described as that movement in which the pad of the terminal phalanx of the thumb is brought into contact successively with the pads of the remaining digits. It is customary to test for this movement by placing the extended terminal phalanx of the thumb on the tip of the little finger when that digit is flexed at the metacarpo-phalangeal joint and extended at the interphalangeal joints [see Figure XIV, (*a*)]. Thus opposition is a complex movement involving simultaneous palmar abduction, internal rotation, ulnar adduction and flexion at the metacarpo-phalangeal joint. Normally the thenar contribution to the movement is dependent on the integrity of the median-supplied thenar muscles. As in the case of palmar abduction the extent to which opposition is retained or disturbed in complete lesions of the median nerve depends upon the extent of an anomalous or double innervation of the *abductor pollicis brevis*, the opponens, and the *flexor pollicis brevis* (see Figure IX).

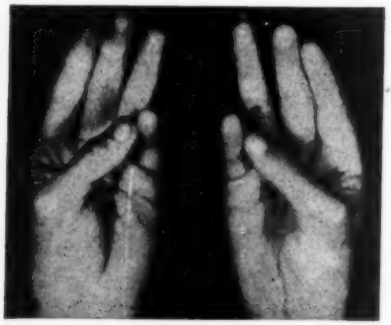


FIGURE IX. Complete lesion of the right median nerve. Opposition correctly executed by thenar muscles supplied by the ulnar nerve.

Flexion at the Distal Phalangeal Joints of the Fingers.—Flexion of the distal phalanx is occasionally possible in the case of the middle or of the middle and index fingers. This can usually be attributed to the well recognized anomalous or double innervation of the relevant sections of the *flexor profundus* by the ulnar nerve. The arrangement of the *flexor digitorum profundus* at the wrist may also account for some persistent flexion of the terminal phalanx in the case of the middle finger. At this level it is usual for the index tendon alone to have separated from the profundus mass. Consequently as the fibres destined for the ring finger contract they may pull on the adjacent fibres which serve the middle finger and in this way produce a weak flicker of flexion which, however, must necessarily be accompanied by simultaneous flexion at the distal phalangeal joint of the ring finger. If the index and middle fingers are isolated and tested individually, this trick action will be prevented.

Flexion at the Proximal Phalangeal Joints of the Fingers.—The proximal phalangeal joint of the ring and little fingers can still be flexed by the over-action of the *flexor digitorum profundus*, which must first flex the distal phalangeal joints (see also Tinel, 1917; Benisty, 1918; Wood Jones, 1919). This is not possible in the case of the index and middle fingers unless the *flexor digitorum profundus* to those digits is supplied entirely by the ulnar nerve.

Flexion at the Metacarpo-Phalangeal Joints of the Fingers.—One's interpretation of trick movements operating at these joints will be determined in large measure by one's conception of the function of the lumbricals and interossei. The actions of these muscles have been investigated in a variety of nerve lesions and are to be described in a separate report. The general conclusion arising from the investigation is that both lumbricals and interossei flex the metacarpo-phalangeal joints and assist the *extensor digitorum communis* to extend the interphalangeal joints. The contention of Pollock (1919) and Mackenzie (1940) that the action of the lumbricals is restricted to the metacarpo-phalangeal joints whilst the interossei only extend the inter-

phalangeal joints, has not been confirmed. The following factors operate in the preservation of flexion at the metacarpo-phalangeal joints of the index and middle fingers in median nerve lesions:

1. The interossei compensate for the paralysed lumbricals (see also Beevor, 1903; Tinel, 1917; Benisty, 1918; Wood Jones, 1919; Wright, 1928). This is the chief factor operating, and for this reason one cannot, from the observation of movement alone, prognosticate on the state of the lumbricals.

2. The anomalous or double innervation of the lumbricals by the ulnar nerve. This is rare in the case of the first lumbrical, but common in the second (Brooks, 1887; Wilson, 1889).

3. Traction on the inert lumbricals exerted by a contracting *flexor digitorum profundus* which has escaped involvement because of an anomalous nerve supply (Pollock, 1919). If this is to be accepted as an explanation, then the flexion at the metacarpo-phalangeal joint must be accompanied by simultaneous flexion at the distal phalangeal joint.

4. "But as was seen to be the case with the flexors of the finger producing an extension of the hand, so under certain conditions the interossei may produce movements ordinarily subserved by the lumbricales. The interossei when extended produce a pull on the tendons of the flexors profundus and sublimis digitorum and when the lumbricales are paralysed, especially if these are shortened, passive flexion of the proximal phalanges will occur" (Pollock, 1919).

Lesions illustrating the trick movements outlined in "3" and "4" above have not been seen in this series. It is agreed that the interossei will produce movements ordinarily subserved by the lumbricals, but it is contended that these are never effected in the manner indicated by Pollock. Moreover, in all the cases personally examined the flexion was not passive but very active.

Extension at the Interphalangeal Joints of the Index and Medius.—It is generally agreed that this movement is correctly performed by the interossei, though in many instances there is a definite weakness compared with the sound side.

COMPLETE LESIONS OF THE ULNAR NERVE.

Flexion of the Wrist.—The movement can be carried out by the *flexor carpi radialis* and by the *palmaris longus* if present.

Adduction of the Thumb.—True ulnar adduction is that movement in which the radial or palmar-abducted thumb is drawn to the radial side of the hand and then swept ulnarwards in contact with the palm. If the movement is carried out in this way the muscles normally responsible for its execution are the *adductor pollicis* and the first palmar interosseous. In this connexion it is of importance to remember that the most medial fibres of the *abductor pollicis brevis* can ulnar-adduct the thumb, but while this is being done the thumb is simultaneously drawn forwards away from the palm. Therefore to minimize or to eliminate the influence of the medial fibres of the abductor when testing for true ulnar adduction as a function of muscles normally supplied by the ulnar nerve, it is essential to request the patient to retain the thumb in contact with the palm as attempts are made to carry it ulnarwards.

In complete lesions of the ulnar nerve it is customary for the patient to retain the ability to ulnar-adduct the thumb in the manner indicated (see also Duchenne, 1867; Beevor, 1903; Tinel, 1917; Pollock, 1919; Highet, 1943).

From the positions of palmar abduction and radial abduction the thumb can be adducted firmly towards and against the radial margin of the hand by the *extensor pollicis longus* (see Figure X). From this position the thumb

can then be swept across the palm under the influence of the *flexor pollicis longus,* which simultaneously flexes the terminal phalanx (see Figure XI). If the tendon of the *extensor pollicis longus* and the terminal phalanx of the thumb are observed as adduction is executed, the appearance of trick action of these muscles can be immediately detected. Frequently when adduction is attempted against resistance from a position of full radial abduction the terminal phalanx of the thumb immediately flexes vigorously whilst the tendon of the *extensor pollicis longus* stands out prominently. It would appear that the contracting *flexor pollicis longus* overcomes the extensor action of the *extensor pollicis longus,* which, however, still contracts firmly on the flexed phalanx to aid adduction (see Figure XII). The action of the extensor ceases immediately the thumb passes the radial margin of the hand.

FIGURE X. Complete lesion of the right ulnar nerve. Powerful adduction of the thumb by the *extensor pollicis longus,* the tendon of which is standing out prominently.

FIGURE XI. Complete lesion of the left ulnar nerve. Adduction of the thumb produced by the *flexor pollicis longus,* which simultaneously flexes the terminal phalanx.

FIGURE XII. Complete lesion of the right ulnar nerve. Powerful adduction of the thumb by the long flexor and extensor. The flexor has overcome the extensor action of the *extensor pollicis longus,* which, however, is contracting firmly on the flexed phalanx to aid adduction. Observe that the little finger is held abducted.

Froment's test (1915) for adductor involvement is based on the trick action of the *flexor pollicis longus.* In this test a thin object is held firmly against resistance between the extended thumb and the radial margin of the palm and index finger. If the terminal phalanx of the thumb flexes in order to retain the object in position it is inferred that the *flexor pollicis longus* is compensating for a paresed or paralysed adductor. However, Froment's test fails to take into consideration the possible trick action of the *extensor pollicis longus,* which, acting alone, enables the patient firmly to retain the object without the development of any flexor deformity (see Figure XIII). Tinel (1917) refers to this action of the *extensor pollicis longus* in connexion with this test, but believes it to be feeble, whereas experience in this particular investigation shows it to be

strong. Froment's test becomes unreliable unless care is taken to exclude the trick action of the *extensor pollicis longus*.

Opposition of the Thumb.—The manner in which this complex movement is impaired in ulnar nerve lesions has been described in this journal (Sunderland, 1944). It has been shown that if opposition of the thumb and little finger is attempted when the intrinsic muscles of the latter digit are paralysed, considerable difficulty is experienced in executing the movement, and on many occasions the thumb fails to reach the little finger. An analysis of this disability has demonstrated that failure to establish contact between the thumb and little finger is due not to any limitation of thenar movement but to the inability of the little finger and fifth metacarpal to participate because of the paralysis of the intrinsic musculature of the little finger. This paralysis results in hyperextension and abduction of the digit at the metacarpo-phalangeal joint, flexion at the proximal interphalangeal joint, and an inability to elevate the fifth metacarpal. Consequently there is no mechanism present for lifting forwards the fifth digit, and for simultaneously flexing it at the metacarpo-phalangeal joint and extending it at the interphalangeal joints, all of which are essential for true opposition [see Figure XIV, (*a*) and (*b*)]. No trick movement on the part of the little finger can compensate for this defect, though in these cases the thumb attempts to do so by fully flexing at the terminal phalangeal

FIGURE XIII. Complete lesion of the right ulnar nerve. Strong adduction of the thumb by the *extensor pollicis longus*. Froment's test would here indicate (erroneously) that the *adductor pollicis* was normal since forced adduction is not accompanied by flexion of the terminal phalanx of the thumb.

(*a*)

(*b*)

FIGURE XIV. (*a*) Normal opposition. The pad of the extended terminal phalanx of the thumb is opposed to the tip of the little finger when that digit is flexed at the metacarpo-phalangeal joint and extended at the interphalangeal joints. (*b*) Complete lesion of the right ulnar nerve. This has resulted in extension at the metacarpo-phalangeal joint, flexion at the interphalangeal joints and an inability to elevate the fifth metacarpal. Consequently when opposition is attempted there is no mechanism present for lifting forwards the fifth digit and for simultaneously flexing it at the metacarpo-phalangeal joint and extending it at the interphalangeal joints. The thumb is attempting to compensate for this defect by fully flexing in an effort to establish contact between the thumb and little finger.

joint in an attempt to throw the terminal pad still further to the ulnar side in order to reach the little finger. The persistent flatness of the dorsum of the hand on the affected side (due to the absence of hypothenar elevation) which is observed when opposition of the thumb and little finger is attempted, contrasts sharply with the rounded contour of the dorsum on the normal side (see Figure XV). Since there is no mechanism to compensate for this deformity, it becomes a reliable guide to lesions of the ulnar nerve involving the intrinsic muscles of the little finger.

Intrinsic Musculature of the Little Finger.—The intrinsic muscles of the little finger are normally responsible for producing hypothenar elevation and flexion and abduction at the metacarpo-phalangeal joint. In complete lesions the first movement, as pointed out above, cannot be compensated for. Flexion at the metacarpo-phalangeal joint may be produced by the overaction of the *flexor digitorum sublimis*, but to accomplish this the proximal interphalangeal joint must first fully flex. Moreover, the absence of the normal flexors of this joint often leads to the unopposed action of the extensors which in turn leads to a hyperextension deformity. Abduction of the little finger can be quite effectively executed by the *extensor digiti quinti*, and in these lesions the little finger, as illustrated in Figure XII, is usually held abducted by this muscle which is now unopposed (see also Benisty, 1918; Wood Jones, 1919). If this digit is passively moved towards the mid-line and then released, it immediately moves out into abduction. This movement should not be attributed to the *abductor digiti quinti* (see also Wood Jones, 1919).

FIGURE XV. Complete lesion of the left ulnar nerve. The photograph illustrates the absence on the affected side of the normal rounded contour of the dorsum of the hand when opposition is attempted. The defect is due to paralysis of the intrinsic muscles of the little finger, and there is no trick action to compensate for it.

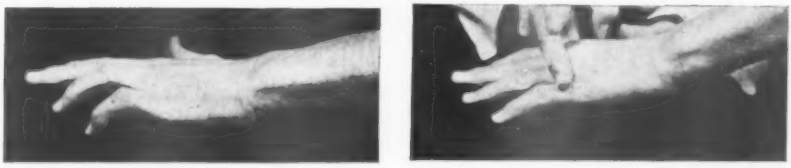
Flexion at the Distal Phalangeal Joints of the Fingers.—The retention of the ability to flex the ring and little fingers at these joints can be attributed to an anomalous or double innervation of the ulnar half of the *flexor digitorum profundus* by the median nerve. Thus in one case in which the ulnar had been severed just above the epicondyle, the patient retained the ability to flex fully all the terminal phalanges. The arrangement of the *flexor digitorum profundus* at the wrist may also account for some persistent flexion in the case of the ring finger. At this level it is usual for the index tendon alone to have separated from the profundus mass. Consequently as the fibres destined for the middle finger contract they may pull on the adjacent fibres which are serving the ring finger and in this way a weak flicker of flexion may be produced. This is necessarily accompanied by simultaneous flexion at the distal phalangeal joint of the middle finger.

Flexion at the Metacarpo-Phalangeal Joints of the Fingers.—In the case of the index and middle fingers the loss of the interossei is adequately compensated for by the lumbricals. This also applies to the ring finger where the third lumbrical is supplied partially or entirely by the median nerve. In the case of the little and ring fingers flexion may be accounted for by: (*a*) the "winding-up" action of the *flexor digitorum sublimis* (see also Tinel, 1917; Benisty, 1918; Wood Jones, 1919); (*b*) the anomalous or double innervation of the ulnar two lumbricals.

Pollock (1919) has described a trick movement which is effected by traction on the inert lumbricals exerted by a contracting *flexor digitorum*

profundus which has escaped involvement because of an anomalous nerve supply. If this is to be accepted as an explanation, then the flexion at the metacarpo-phalangeal joints must be accompanied by simultaneous flexion at the distal phalangeal joint.

Extension at the Interphalangeal Joints of the Fingers.—The effect of lesions of the ulnar nerve on extension at the interphalangeal joints of the fingers is again determined by the respective actions of the lumbricals and interossei, and attention is called to the statement made earlier that both lumbricals and interossei extend the interphalangeal joints.



(*a*) (*b*)

FIGURE XVI. Complete lesion of the left ulnar nerve. (*a*) Attempts to extend the fingers result in hyperextension at the metacarpo-phalangeal joints of the ring and little fingers with flexion at the interphalangeal joints. (*b*) If hyperextension at the metacarpo-phalangeal joints is prevented, then the ring and little fingers can be almost fully straightened.

It is a matter of common observation that in these cases extension of the middle and distal phalanges of the index and medius is undisturbed, though on occasion weakened. Pollock (1919) and Mackenzie (1940) attribute this to the preservation of the first and second dorsal interossei which, they believe, are in these instances partially or exclusively supplied by the median nerve. The number of cases in which these interossei are definitely paralysed is, however, considerable and therefore some other factor must be operating. Observations made during this investigation leave no doubt that the radial two lumbricals acting with the *extensor digitorum communis* are responsible. In the case of the ring and little fingers no such compensatory mechanism is available unless one or both ulnar lumbricals escape because of an anomalous or double innervation by the median nerve. I have observed this frequently in the case of the ring finger, but never in the case of the little. If, however, these two digits are immobilized in slight flexion at the metacarpo-phalangeal joints (see also Beevor, 1903) or if their long flexors are inactive and not shortened (see also Wright, 1928), the middle and distal phalanges can be extended by the long extensors passing to those fingers (see Figures XVI and XVII). An investigation into the actions of the lumbricals, interossei and *extensor digitorum communis* on the middle and distal phalanges has demonstrated that, contrary to the opinions of Duchenne (1867) and Benisty (1918), the *extensor digitorum communis* can extend, partially or completely, the middle and distal phalanges. In order that this muscle may extend its action to the distal phalanges, however, it is essential that hyperextension at the metacarpo-phalangeal joints should be prevented, and normally this appears to be the

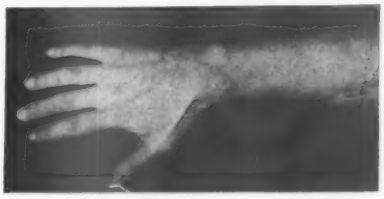


FIGURE XVII. Complete lesion of the right ulnar nerve. Extensive loss of tissue over the ulnar aspect of the forearm involving the long flexors to the ring and little fingers. In this case the ring and little fingers can be almost completely straightened. Radial margin of an extensive pedicle graft to the forearm is visible.

function of the lumbricals. Such hyperextension places the *extensor digitorum communis* at a mechanical disadvantage and introduces the tendon action of the long flexors on the interphalangeal joints. Wood Jones (1919) has drawn attention to the ability of the *extensor digitorum communis,* acting alone, to extend the two terminal phalanges in ulnar nerve lesions, though in this series this has been observed only when the metacarpo-phalangeal joints have been fixed in a neutral or mildly flexed position.

Abduction of the Fingers.—This movement is normally executed by the dorsal interossei. Following paralysis of these muscles abduction can still be executed by the digital extensors (see also Tinel, 1917; Benisty, 1918; Wood Jones, 1919; Pollock, 1919; Woods, 1919; Forrester-Brown, 1920; Wright, 1928). It is said that this trick action of the extensors is eliminated if the test is carried out on a plane surface in such a way that elevation of the fingers from the surface is prevented. This certainly has the effect of preventing abduction of the middle and ring fingers, but despite these precautions a good range of abduction can be obtained in the case of the index finger without lifting it from the plane surface. This abduction is executed principally by the *extensor digitorum communis* tendon and perhaps by the first lumbrical (Benisty, 1918). In addition, the movement may be assisted by radially abducting the thumb. This pulls on the inert dorsal interosseous and thereby imparts a movement of abduction to the index finger. Therefore, when assessing the abductor function of the interossei no reliance can be placed on movement alone of the index finger unless the first dorsal interosseous is felt to contract. The fingers may also be eased apart on the plane board by deviating the hand at the wrist alternately in ulnar and radial directions. In addition the fingers may be opened in a fan-like manner by fixing either the index or little finger on the surface and then splaying the fingers away from the fixed point. These deceptive movements will be eliminated if the wrist is stabilized and movements are restricted to the digits. Reliable information concerning the state of the dorsal interossei can be obtained by: (*a*) Palpating the first dorsal interosseous in forced abduction of the index finger. One should, however, keep in mind the possibility of an anomalous innervation of this muscle by the median nerve, although this must be regarded as being very rare. (*b*) Ascertaining if the middle finger can be moved to and fro in the plane of the hand across the mid-line of that digit.

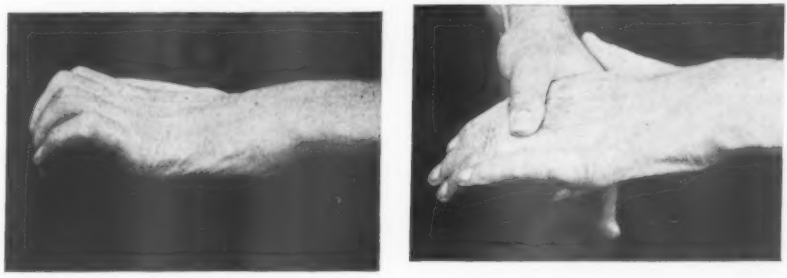
Adduction of the Fingers.—Adduction of the fingers is normally executed by the volar interossei, but in their absence the fingers can be drawn together by flexing them (see also Tinel, 1917; Wood Jones, 1919; Pollock, 1919; Wright, 1928). To eliminate this trick action of the long flexors the movement of adduction should be taken out on a plane surface and flexion of the fingers prevented. Even under these conditions the index finger can be adducted by the *extensor indicis proprius* (see also Duchenne, 1867; Tinel, 1917; Wood Jones, 1919; Forrester-Brown, 1920; Wright, 1928). The adductor action of this muscle and the abductor action of the *extensor communis* tendon to this finger can be demonstrated in most cases in which the interossei are paralysed. Cases have also been seen in which the ring finger could still be adducted to the middle finger, presumably under the influence of its extensor tendon. No such compensatory mechanism is present in the case of the little finger. Therefore when the volar interossei are being tested actual movement of the index and ring fingers should be disregarded. Loss of adduction of the fifth finger is the most reliable sign of involvement, since it is the only movement which cannot be simulated (see also Benisty, 1918). If, however, a thin object can be held firmly between the ring and little fingers and between the ring and middle fingers without any flexion developing in the digits, then the volar interossei are contracting.

COMBINED LESIONS OF THE MEDIAN AND ULNAR NERVES.

Flexion of the Wrist.—In these cases the movement can be carried out by the *abductor pollicis longus* (see also Duchenne, 1867; Beevor, 1903; Tinel, 1917; Benisty, 1918; Wood Jones, 1919; Pollock, 1919).

Thumb.—According to Benisty (1918), movements of flexion, opposition and adduction of the thumb are lost. Adduction of the thumb to the radial side of the hand and index finger can still, however, be carried out by the *extensor pollicis longus* (see also Highet, 1943). Care should again be taken to exclude this trick action when employing Froment's test.

Flexion of the Fingers.—The fingers may be flexed by the tendon action of the paralysed long flexors (see also Tinel, 1917; Benisty, 1918; Wood Jones, 1919; Pollock, 1919; Woods, 1919; Forrester-Brown, 1920; Wright, 1928),



(*a*) (*b*)

FIGURE XVIII. Complete lesions of the median and ulnar nerves in the upper arm. Recovery of the long flexors only. (*a*) Attempts to extend the fingers result in hyperextension at the metacarpo-phalangeal joints and flexion at the interphalangeal joints. (*b*) If hyperextension at the metacarpo-phalangeal joints is prevented, then the range of extension at the interphalangeal joints can be increased.

but to do this the wrist is first hyperextended. In this way the long flexor tendons are passively tightened and the interphalangeal joints are pulled into flexion. Great care must be taken to guard against this trick action, which can be easily unmasked by testing for flexion of the fingers with the wrist in the neutral position. Incidentally such flexion may be executed in separate lesions of the median and ulnar nerves, but the best examples are provided by combined lesions.

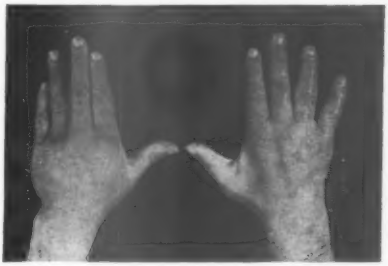


FIGURE XIX. Complete lesions of the median and ulnar nerves in the midforearm. This patient can completely extend the digits by means of the *extensor digitorum communis* acting alone and without any external assistance.

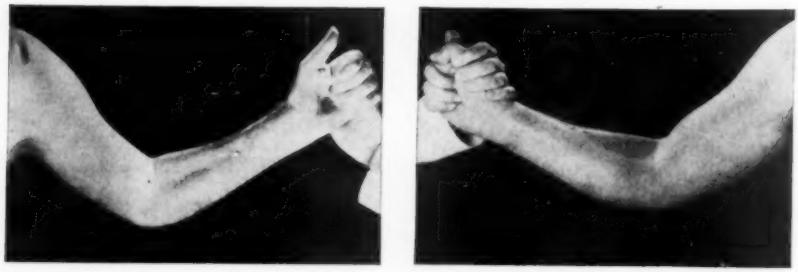
Extension at the Interphalangeal Joints of the Fingers.—If the digits are immobilized in slight flexion at the metacarpo-phalangeal joints or if the long flexors are inactive and not shortened, the distal two phalanges can be extended by the long digital extensors (see Figure XVIII). In one case the *extensor digitorum communis*, acting alone and without any external assistance, could extend the interphalangeal joints of all the fingers (see Figure XIX).

LESIONS OF THE MUSCULO-CUTANEOUS NERVE.

No lesions of the musculo-cutaneous nerve have been present in this series. Two cases in which the lateral cord of the brachial plexus was involved

presented an opportunity for studying flexion of the elbow joint when the biceps, brachialis and *pronator teres* were paralysed (see Figure XX). Full flexion against mild resistance could be carried out in both by the brachio-radialis (see also Benisty, 1918; Tinel, 1917; Wood Jones, 1919; Forrester-Brown, 1920). In lesions of the musculo-cutaneous nerve *pronator teres* also acts as a flexor of the elbow joint, but at the same time pronates the forearm. In complete combined lesions of the musculo-cutaneous and radial nerves elbow flexion can still be executed by the *pronator teres*, which simultaneously pronates the forearm (Wood Jones, 1919; Woods, 1919; Forrester-Brown, 1920). Benisty (1918) maintains that in such combined lesions "active flexion of the forearm becomes quite impossible".

The extent to which the flexors and extensors of the wrist participate under these conditions is uncertain, for any effect they might have is obscured by the strongly contracting *pronator teres*. Duchenne (1867) claims to have demonstrated weak elbow flexion by the carpal flexors after the wrist



(*a*) (*b*)

FIGURE XX. (*a*) Paralysis of the left biceps, *brachialis anticus* and *pronator teres*. Flexion of the elbow produced by the brachio-radialis. (*b*) Elbow flexion on the normal side.

has been fixed in extension. According to Beevor (1904), this supplementary action is negligible, but he described cases in which, with the brachio-radialis inactive and the biceps contracting feebly, the patients "in flexing the elbow first pronated the forearm, the extensors of the wrist then contracted hyper-extending the wrist and finally the elbow very slowly flexed". He was, however, unable to decide whether this flexion was executed by the *pronator teres* and the carpal flexors or by the *pronator teres* and the carpal extensors. Wright (1928) reports supplementary flexion in a case in which there was a trace of biceps power but no other elbow flexors and no carpal extensors. Flexion was accomplished "by first pronating the hand and in that position making use of a much hypertrophied *extensor digitorum communis* to aid the weak biceps". It would appear, however, that the entire movement in this case could be attributed to the *pronator teres*. This series did not afford an opportunity to investigate this question.

NERVE LESIONS OF THE LOWER EXTREMITY.

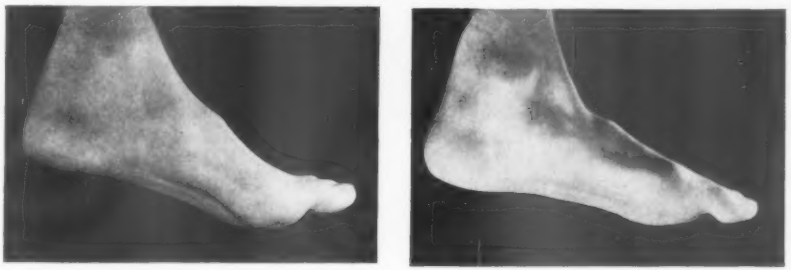
The leg lacks the variety and complexity of voluntary movements present in the upper limb and consequently deceptive voluntary movements in this part are not encountered to nearly the same extent. The following points, however, are worthy of consideration:

1. The position in which the patient is postured is most important when testing leg movements.

If voluntary power is examined for with the patient lying on his back with his heel resting on the couch, almost any conclusion may be arrived at. The patient has only to push or to pull against his heel at a fixed point to produce movements of his foot in either direction; and this push or pull may be effected by any muscle capable of taking a leverage from the couch (Wood Jones, 1919).

The influence of gravity and resistance must always be eliminated by carrying out all movements on a suitably placed smooth board.

2. In complete lesions of the medial popliteal nerve some patients retain the ability to plantar-flex the foot by contracting the *peroneus longus* (see also Wood Jones, 1919). Normally this muscle acts with the other muscles supplied by the lateral popliteal nerve to give range and variety to combined movements of dorsiflexion and eversion. It would appear, however, that when the normal plantar flexors are paralysed, the *peroneus longus* can be, on occasion, dissociated from the remaining muscles of its group to supplement for the paralysed muscles. In complete lesions of the lateral popliteal nerve a flicker of dorsiflexion of the foot has been seen to follow strong plantar flexion of the toes (see also Pollock, 1919). This introduces the tendon action of the digital extensors which in turn leads to dorsiflexion of the ankle.



(*a*) (*b*)

FIGURE XXI. Complete lesion of the left posterior tibial nerve below the supply to the gastrocnemius. (*a*) Position at rest. (*b*) Limited plantar flexion of the big toe by dorsiflexing the foot with the *tibialis anterior*, the tendon of which is standing out prominently. This movement introduces the tendon action of the paralysed *flexor hallucis longus* and causes the toe to bend downwards.

This movement is analogous to the extension of the wrist produced by the tendon action of the *extensor digitorum communis*. No case has been seen in which plantar flexion of the ankle could be obtained by dorsiflexing the toes.

3. In complete lesions of the lateral popliteal nerve error may arise if the slight adduction and inversion produced by the *tibialis posterior* are attributed to the *tibialis anterior* (see also Tinel, 1917; Benisty, 1918; Forrester-Brown, 1920). If the *tibialis posterior* is responsible, then there is no associated dorsiflexion of the foot as would occur if the *tibialis anterior* were contracting.

4. In complete lesions of the medial popliteal nerve the toes may be plantar-flexed by strongly dorsiflexing the ankle, which introduces the tendon action of the digital flexors (see Figure XXI; see also Wright, 1928). If the ankle is immobilized, however, a flicker of plantar flexion of the toes can still be obtained by first strongly dorsiflexing the toes and then suddenly releasing them. This permits the toes to rebound into a position of plantar flexion (see also Benisty, 1918). As in the hand, pseudo-plantar flexion of the toes may be produced by the claw effect of the long digital extensors. These, owing to the absence of the intrinsic muscles, bring about hyperextension at the metacarpo-phalangeal joints and thereby introduce the tendon action of the

long flexors (see also Forrester-Brown, 1920). Deceptive dorsiflexion of the toes can be similarly executed in complete lesions of the lateral popliteal nerve. In these cases plantar flexion of the foot introduces the tendon action of the digital extensors (see also Wright, 1928), whilst rebound movements of extension follow strong plantar flexion of the toes.

5. The attachments of the *rectus femoris* are such that the tendon action of this muscle, which can be called into action by hyperextending the hip, may give some extension of the knee following paralysis of the normal extensors of that joint. A weak extension effect may also be imparted to the knee by the pull of *tensor fasciæ latæ* (see also Forrester-Brown, 1920).

SUMMARY.

The trick or supplementary movements which have been observed in 170 cases of peripheral nerve injuries have been described. These are voluntary movements which can still be effectively carried out even when those muscles customarily held to be responsible for their execution have been deprived of their nerve supply.

Trick movements have been recorded in isolated and combined lesions of all the main peripheral nerves.

The immediate recognition of such movements in peripheral nerve injuries is of considerable importance since the failure to detect them will lead to false estimates of the extent of the nerve lesion and the progress of regeneration. This will in turn result in incorrect diagnoses and in unjustified optimism concerning either the progress of spontaneous regeneration or the efficacy of a surgical procedure designed and undertaken to facilitate regeneration.

Attention has been directed to the care which must be exercised in testing voluntary movements and in estimating, solely on the basis of the derangement of movement, the condition of any muscle or muscles.

ACKNOWLEDGEMENTS.

I wish to express my thanks to the Director-General of Medical Services for permission to publish this paper, and to Mr. L. Preston for the photographs which accompany it.

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FRACTURES OF FACIAL BONES.[1]

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Major, Australian Army Medical Corps.

THIS paper concerns injuries to the upper part of the face, excluding the mandible, except to recognize that it is often injured along with the upper facial bones. The upper facial region is, perhaps, less generally understood and it is of special importance to air force medical officers because of a special incidence of upper facial injuries from the direct violent impact of pilots on their cockpit cowling or instrument panel in air crashes.

The facial skeleton is well adapted to withstand trauma in a protective capacity not only to the eyes but to the skull base. The orbital ridges, the malar prominences and the tooth-bearing maxillary alveolar process are of strong thick bone, but between and beneath these is a flimsy mass of easily crushable plates about the nasal cavity and its accessory sinuses. These flimsy bone masses act as cushions or shock absorbers so that with direct violence the stronger prominences which take the impact are, themselves, not primarily comminuted, but are displaced as whole masses or telescoped and impacted into these deeper bony elements, which are crumpled and comminuted.

Because of the very comminuted and impacted nature of these facial fractures, if early and adequately reduced, they generally stay reduced without elaborate retentive mechanisms. Conversely, if the fractures are not reduced, they early and easily become fixed in malpositions and irreducible. Because of the good local blood supply there is rapid fixation of the fracture lines, not necessarily by bony union, but by hæmatoma and its organization.

It is often thought and written that there should be no interference with facial fractures while there is hæmatoma or swelling. There are reasons which may contraindicate interference (we shall come to these later), but this is not the rule, for the principle of early reduction of fractures is even more important for facial fractures—it may be the only opportunity. Disfigurement is the least of a line of sequelæ we see from unreduced facial fractures—obstructed airways, visionary upsets, including diplopia, or dental malocclusion.

It can be stated as the pivot of these remarks that no amount of remote plastic surgery or camouflage can ever compensate for misplaced or malunited face bones.

There is a critical period for facial injuries; it is about two weeks. Only in that period can proper reduction be easily effected. Any medical service organization for these injuries must respect this, and as it may be impossible or impracticable for the focusing of all facial injuries in special units within that period, it does mean that the forward surgeon in the medical reception station or casualty clearing station must carry out the primary treatment. If the forward surgeon fails to take the opportunity which only he may have in this critical period of replacing face bones, he is condemning his patient to incorrectible disability or deformity or else to a long period of hospitalization and plastic operations with often an equivocal or compromising end-result.

[1] A lecture given to air force medical officers in Melbourne, September, 1942. Accepted for publication on March 9, 1943.

For that reason is set out what every potential forward surgeon must know of these facial injuries: (i) the types of fractures he can expect to see; (ii) the main points in their recognition; (iii) how he would be expected to manage them.

TYPES OF UPPER FACIAL FRACTURES.

The possible fractures of this region may seem protean, as in detail they are, but in principle there are prototypes. All are explicable in terms of the direction and degree of violence and of the local anatomy. On these desiderata McIndoe[1] has set out a useful classification which has a rational bearing on treatment: (*a*) frontal violence fractures in which the naso-maxillary region takes the brunt; (*b*) lateral violence fractures in which the malar-maxillary region is chiefly involved. And there are combinations of both.

FIGURE I. First degree naso-maxillary or frontal violence fractures. The heavy black lines indicate the usual lines of fracture which are present in various combinations and with various displacements.

Frontal Violence or Naso-Maxillary Fractures.

(*a*) Lesser degrees of violence produce what McIndoe calls "first degree naso-maxillary fractures" (see Figure I). The first line of weakness is fractured, that is, about the nasal bones and the frontal processes of the maxillæ. The nose may be flattened or distorted to one side. The nasal septum is buckled, dislocated from its lower attachments or broken, and there may be minor grades of impaction of the forward nasal elements into the ethmoidal region.

(*b*) Greater violence in the same direction produces second degree naso-maxillary fractures (see Figures IIA and IIB). The violence is not expended in local fracture comminution about the nasal arch and the next line of relative bony weakness succumbs. This fracture follows lines on each side: (i) vertically down from the middle of the infraorbital ridge through the infraorbital canal and across the front of (or below) the antrum to the floor of the nasal cavity; (ii) back across the orbital floor to the spheno-maxillary fissure and the optic foramen; (iii) forward across the medial orbital wall—ethmoid and lachrymal bones—to the fronto-nasal region. The entire pyramidal block between this ring of fracture lines (as indicated by the dotted portion of Figures IIA and IIB) is impacted back between the malar and antral remnants, crumpling up the *laminæ papyraceæ* of the ethmoid. Sometimes the lower transverse part of the fracture line extends back below the malar bones to give a complete transverse fracture of the maxilla with a virtual separation of alveolar and palatal elements from the rest of the maxilla.

(*c*) Third degree naso-maxillary fractures are produced by still greater violence beyond the shock-absorbing capacity of the local free face skeleton, so that there is associated fracture of the skull base, the cribriform plate or the anterior fossa. The frontal sinuses are often involved in these fractures

and the prognostically important condition of cerebro-spinal rhinorrhœa ensues, that is, leakage of cerebro-spinal fluid through frontal sinus, cribriform plate of ethmoid or even the sphenoidal sinus.[2]

In short, these three degrees of naso-maxillary impaction indicate: (*a*) the local fractures about the external nasal skeleton; (*b*) the gross comminutions of the internal nasal bones, with collapse of the entire nasal block, manifest in a "dish face" deformity; (*c*) the naso-maxillary fractures associated with fractures of the skull base.

FIGURE IIA.

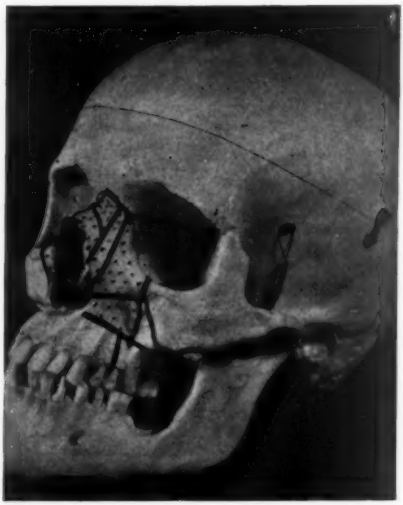

FIGURE IIB.

Figures IIA and IIB show second degree naso-maxillary or frontal violence fractures. The heavy black lines indicate the usual lines of fracture. The dotted area indicates the pyramidal block of bone which is impacted backward in varying degree.

Lateral Violence or Malar-Maxillary Fractures.

Again there are degrees of telescoping impaction varying with the violence (see Figure III).

First Degree Malar-Maxillary Fracture.—With moderate violence the malar itself is not usually comminuted, but is shorn off its frontal zygomatic and maxillary moorings. There may be some degree of impaction of the malar into the antrum.

Second Degree Malar-Maxillary Fracture.—Greater violence may comminute the malar itself, and it or its fragments are impacted down into the antral shock absorber. The antral walls are comminuted. There is collapse of the infraorbital ridge and of the infraorbital plate. This may cause depression or prolapse of the globe, often manifest in diplopia.

Third Degree Malar-Maxillary Fracture.—Still greater violence again beyond the protective capacity of the local shock-absorbing mechanism is passed onto deeper structures. The skull or the alveolar arch and palate regions are fractured, depending on whether the lateral violence is directed more upwards or downwards.

Skull fracture thus may be part of the complex with these face injuries, but by no means always.

THE DIAGNOSIS OR RECOGNITION OF UPPER FACIAL FRACTURES.

All these fractures are very easily overlooked unless one actively suspects them and looks for them. We could well acquire the habit with any face or head injury of asking: "Has this man a face fracture?" The possibility should always be excluded by clinical examination, just as we examine pupils or look for blood from the ears.

Local swelling or hæmatoma, soft tissue injury or association with other injuries, possibly at the time more serious, are the usual reasons why especially the lesser degree of facial fracture is so often missed. There is no legitimate excuse, however, for neglect at least to note a facial fracture and to arrange that it is adequately treated as soon as the patient's general condition permits.

FIGURE III. Malar-maxillary or lateral violence fractures. The heavy black lines indicate the usual lines of fracture.

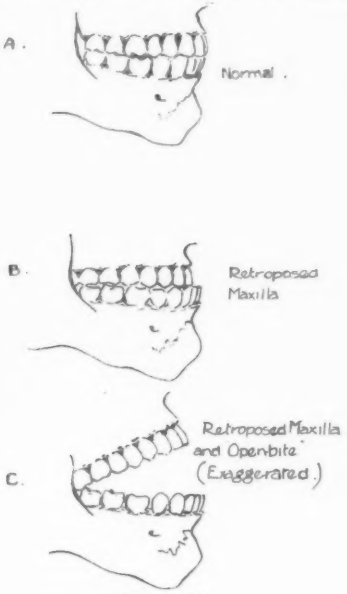

FIGURE IV.

Even gross displacements may be masked by local conditions of swelling or lacerations. One cannot rely on spot diagnosis, no single sign is pathognomic; but careful and systematic palpation, always with a comparison of both sides, is the best guide.

Apart from possible signs common to all fractures, points to observe are:

(A) For suspected frontal violence fractures: (*a*) Flattening and widening of the nasal arch may be present. (*b*) Retroposition of the central face—the upper lip may appear relatively prominent. Grosser types have a typical "dish face" or mongoloid appearance. (*c*) The inner canthus of the eye may be displaced. (*d*) Examination must include a close scrutiny of the upper alveolar arch for retroposition, mobility, dental malocclusion or open bite (see Figure IV). It may even be necessary to study the bite on dental models. (We shall return to this.)

(B) For suspected lateral violence fractures: (*a*) In the gross case the patient has a typical lopsided appearance of the face, masked by degrees of swelling. The eyeball may be lowered and the lower lid may appear ectopic from collapse of the infraorbital ridge. (*b*) Systematic palpation of the infraorbital ridges, the zygomatic arches and in the upper buccal sulcus, both sides always being compared, will detect any irregularity or difference. (*c*) Anæsthesia and sometimes paræsthesia of the infraorbital nerve is often present. (*d*) Diplopia on looking to the sides is usually present with any degree of displacement of the infraorbital plate.

Only active and careful palpation in all suspected cases will prevent many facial fractures from being missed until in a few weeks we are confronted with obvious defects, maybe too late then for any easy correction (see Figures XIIA, XIIB, XIII and XIV).

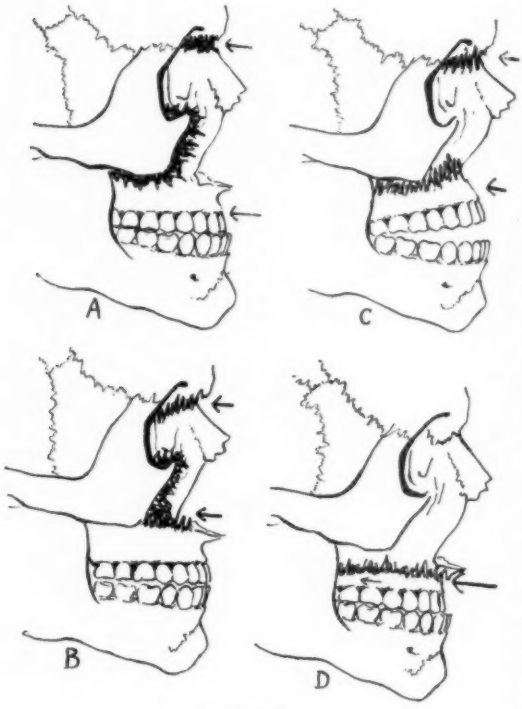

FIGURE V.

We should enlist the cooperation of the dental officer early. So often we see face injuries in which soft tissue wounds about the mouth are repaired and a few days later a dental officer is asked to fix a fracture by some intraoral means. Without jeopardizing a soft tissue repair, it may be impossible for him to obtain impressions necessary for splint construction or to carry out intraoral manipulations necessary for fixation. Local reaction or trismus may necessitate compromises of fixation. Undue delay in obtaining absolute fixation aggravates sepsis and pain and instigates a vicious circle which prolongs discomfort and detracts from the best end-result.

In assessing the significance of maxillary displacements, we should note that dental malocclusion and retroposition of the upper alveolar arch do not necessarily mean alveolar fracture, for as we have indicated the middle third of the face may be displaced as a whole block, including the alveolar segment, which is not separated from the rest of the maxilla (see Figure V, A). The converse may also be true, that is, there may be a middle third face fracture and yet no retroposition of the alveolar segment (see Figure V, B). This may happen if injury is received with the teeth clenched, a complete transverse fracture of the maxilla associated with the typical second degree fronto-maxillary fracture being produced. The middle third of the face may then be well impacted backwards, leaving the separated alveolar segment forward in normal relationship with the lower

jaw. If there is retroposition with an open or asymmetrical bite, it must certainly mean a transverse maxillary fracture, with upward impaction into the antral region, and impaction may destroy mobility as an indication of fracture (see Figure V, C). Sometimes the same violence as would give a middle facial fracture, if received lower down on the alveolar region, may cause a clean shearing off of the alveolar segment without any fracture or displacement of the upper maxilla at all (see Figure V, D).

These fractures can be diagnosed clinically by a careful consideration of retroposition, mobility and malocclusion of the alveolar segment from the mouth.

To Summarize:

1. If with a displaced alveolar segment there is no mobility, the alveolar segment is either still intact with the maxilla and displaced with it (as in Figure V, A) or else there is a transverse fracture with severe impaction into the upper segment (as in Figure V, C). In the latter case as well as the fixed retroposition there will be an open bite or tilting deformity of the alveolus.

2. If there is a moderate degree of mobility along with a retroposition and open bite, there is a transverse fracture of the maxilla with some impaction of the lower into the upper segment.

3. If with displacement there is gross mobility in all directions, there is a transverse fracture and so much destructive comminution of the upper segment that there is no fixation by impaction.

4. Then there may be unilateral dental malocclusion due to localized fractures which result from localized blows. These will vary in mobility with the degree of impaction into the antral superstructure.

Radiographs should be taken whenever these fractures are suspected, but the diagnosis can and should be made early by careful clinical examination without primary reliance on X-ray pictures.

MANAGEMENT OF UPPER FACIAL FRACTURES.

If reduction is effected early, elaborate splints and retentive apparatus are not usually required. Most of the more elaborate contraptions which are seen in the journals and in special clinics, are for those cases in which reduction has not been effected in the critical period because of neglect or contraindications.

The contraindications to early manipulation may be set out as follows:

1. Third degree frontal and lateral violence fracture, that is, when there is fracture of the skull base or anterior fossa, and certainly if the condition of cerebro-spinal rhinorrhœa exists. If it does, the complication of intracranial septic conditions, meningitis and abscess is always potential, and any manipulation may interfere with natural "walling off" processes.

2. Any association of intracranial or other injuries, as would contra-indicate operation of any type. This does not mean that the facial fracture should be neglected beyond the shortest period for interference to be safe.

3. Any established local sepsis as when soft tissue lacerations of long standing have become infected.

4. Unfavourable anæsthetic indications and facilities (this will be discussed later).

In practice, treatment can well be considered under the following headings (McIndoe): (i) The ideal immediate or early treatment within the critical period of two weeks. (ii) After two weeks and up to about three months—for those cases in which earlier treatment has been impossible or contraindicated. This includes most cases in which severe head or other

associated injuries have occurred. (iii) Remote treatment: this is after the three months' period when malunions are established and when plastic substitution or camouflage therapy is all that can be offered.

Early Treatment.

Anæsthesia.

Local anæsthesia is most unsatisfactory when disimpactions of the face bones are to be carried out. In the past, anæsthetic difficulties have been one of the chief reasons why many ordinary malar depressions and nasal fractures have remained unreduced. For minor manipulations such as these,

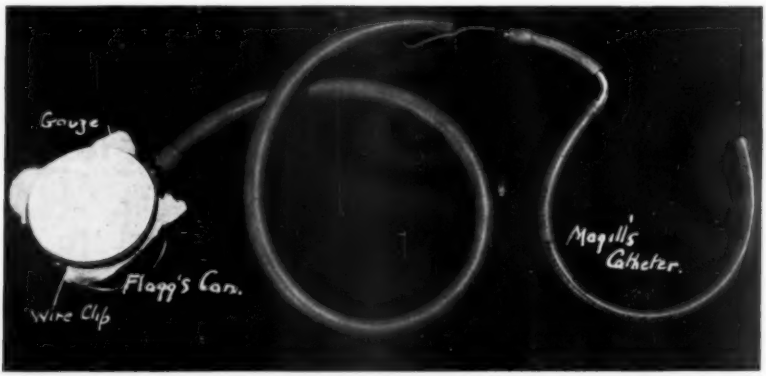

FIGURE VIA. Flagg's can. A simple means of administering endotracheal inhalation anæsthesia for face injuries when a machine is not available. The measurements shown in Figure VIB are approximate proportions suitable (a Nestlé's condensed cream can is very suitable). The metal tube projection on the tin is connected to a Magill's catheter by rubber tubing, whose length must be as short as possible and yet allow the anæsthetist to keep away from the operation field. No diameter in the system should be less than that of the catheter.

FIGURE VIB. Another view of Flagg's can.

"Pentothal" is satisfactory. Due care must be taken to have a pillow under the shoulders and the head well back. Only short evanescent anæsthesia is required as these manipulations only take seconds and there is no need to abolish the cough reflex for any period.

For all the more gross fractures in which (*a*) there is much soft tissue injury, (*b*) manipulation is likely to precipitate bleeding into the airway, or (*c*) some time must be spent, as by the dental officer in taking impressions, there is no alternative but the use of endotracheal anæsthesia, with a packed off pharynx. This does not necessitate a machine—a Flagg's can or some such type of simple system is quite adequate for these circumstances when an anæsthetic machine is not available (see Figures VIA and VIB).

Soft Tissue Injuries.

Missile injuries of the upper part of the face may be accompanied by notable soft tissue damage mostly about exit wounds, but the direct violence

injuries of which I have been speaking usually produce remarkably little soft tissue laceration relative to the bone damage, though plenty of bruising.

Débridement.—Débridement should be carefully done, the surgeon relying on soap and water. One cannot be too careful of spirit about the eyes. Any

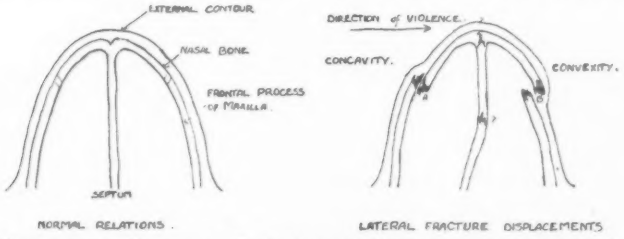

FIGURE VII. Diagram to illustrate typical displacements in a lateral fracture of the nose. At A the displaced nasal bone is locked inside the corresponding frontal process of the maxilla. At B the nasal bone is displaced outside the corresponding frontal process. The septum may be buckled, broken or dislocated from its attachments. Intranasal manipulation must include forward traction with rotation to the side of the convexity (as it were to exaggerate the deformity) so as to unlock the fragments at A to make possible reduction of the fractures.

dirt or grease ingrained should be removed now by rubbing with gauze on the finger or a stiff brush, even a wire brush. If left, the tattooing that it causes is a permanent disfigurement.

Wound Excision.—Wound excision for face wounds can be accepted in a different sense to that of other regions as it must err on the conservative side.

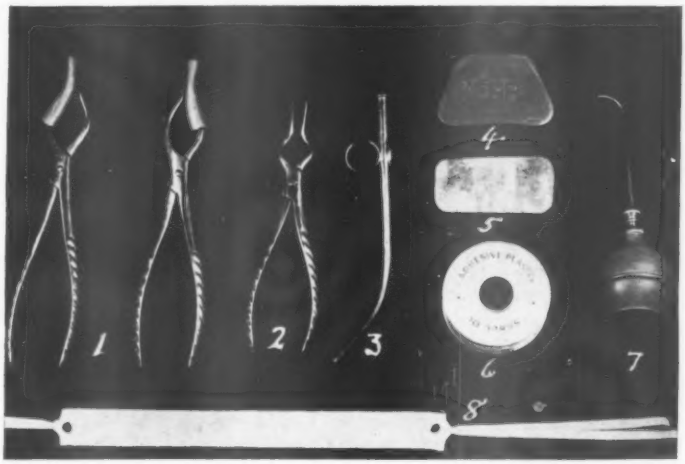

FIGURE VIII. Armamentarium for reduction of nasal fractures. 1: Walsham's forceps (the large blade which goes outside the nose is covered with rubber tube); 2: Asch's septum forceps; 3: a fine ended suction nozzle (Magill); 4: dental impression compound (Kerr); 5: sheet lead; 6: narrow adhesive strapping; 7: dental chip syringe with ice water; 8: adhesive strapping one inch wide, folded at each end with tapes attached, for use as in Figure IX.

Only unduly contused tags, which cannot survive, should be removed. Edges can be finely trimmed with eye scissors, every advantage being taken of the remarkable blood supply of the face.

Repair or Suture.—The question of repair or suture depends on the wound, the time factor and local conditions. Within twelve hours a clean wound, without loss of tissue, can be sutured; but no attempt at primary repair in the "civilian surgery" sense should be carried out where there is loss of tissue. For these wounds, or when time has elapsed, any established defect should be left. Loose flaps should be anchored in their correct positions by a minimal number of sutures. Where possible, bare bone should be covered, and the practice of suturing skin to mucous membrane about the edge of defects about mouth and nose is a good one. It prevents undue retraction and scarring and makes subsequent repairs easier.

Drainage.—Drainage should be provided under any loose flap, where pocketing or collection of hæmatoma, prone to become infected, may collect. A twisted silkworm gut drain is most effective.

FIGURE IX. Arrangement of strapping to maintain position of a moulded nasal splint. The mould A is made of dental impression compound. Just before this sets, sheet lead B is impressed into the mould. Strapping C is arranged as shown; the main band is tied with tapes D behind the head.

Fractures.

The Local Nasal Fractures (First Degree).—The broken nose may be comminuted and flattened or pushed to one side, like the ordinary fracture of the nose from a side punch. All these fractures require intranasal manipulation. Wiggling from the outside or arrangements of strapping from the outside effect nothing. General anæsthesia is required. The nasal bones are often impacted inside or outside the corresponding frontal processes of the maxillæ, and this cannot be corrected except by lateral and forward manipulation from within (see Figure VII). Walsham's forceps (see Figure VIII) are used for disimpaction and corrective manipulation. No elaborate retention is required, but a mould of dental impression compound reinforced by a piece of sheet lead is used to control hæmatoma, to act in some degree as a splint and to give protection from minor trauma (see Figure IX). If carefully moulded, this stays fixed with the aid of strapping and tape tied behind the head as shown. The top end of the mould is also anchored to the forehead with strapping.

The position of the septum must be checked and manipulation, as indicated, is done with Asch's septum forceps. Any hæmatoma of the septum, which is already present or forms subsequently, should be evacuated through a small incision. These hæmatomata readily become infected, causing cartilage destruction, which will later lead to collapse of the nose.

If all the ordinary broken noses were actively treated along these lines—which, when all is said and done, are those for any fracture—there would not be the population with crooked, humped noses and unilateral nasal obstruction arising from uncorrected fractures of nasal bones and septum. These are the people who a few years later flood the nose and throat departments of our hospitals and await submucous resection of a distorted septum for relief of nasal obstruction, to say nothing of all those with disfiguring collapsed noses from septic destruction initiated by septal hæmatoma or following more radical submucous resection operations.

The More Gross Naso-Maxillary Fractures (Second Degree).—Here early manipulation under general anæsthesia must include not only strong forward traction with the nasal manipulation forceps to bring the central bone mass forward, relieve the impaction of the ethmoidal air cells and correct the step deformity of the intraorbital ridge on either side, but the lower maxilla and alveolar process must also be disimpacted and manipulated forward. This can be done with lion forceps, protected by rubber, which grip the upper buccal sulcus and palate regions. Reduction is effected by a rocking movement and forward traction. Only enough force to produce disimpaction is indicated and soft tissues must be duly cared for. Local alveolar displacements can be reduced manually.

After reduction of the nasal elements intranasal splints, of which no end have been designed, should not be used. Mucous membrane (just as in the mouth) will not tolerate continued pressure for any lengthy period. So, too, any intranasal packing or anything which interferes with natural drainage should not be used. If after reduction there is a tendency for recollapse of the nasal skeleton, rubber tubes should be used to maintain patent airways and support the nose. An outer contour mould of dental impression compound may be used as before. Provision can be made for the support of this in any external appliance indicated for associated maxillary fractures.

The transverse maxillary and alveolar process fractures associated with this type of injury do require a period of fixation in the reduced position with correct dental occlusion. Persons with fractures of this kind should be sent as soon as possible to a special unit where facilities for the appliances indicated for fixation are available. Early cooperation of a dental officer should be enlisted, for it is always easier to get impressions early. These can be sent on with the patient and if disimpaction has been adequately carried out, further anæsthesia at the special unit will be unnecessary. Temporary fixation by interdental and intermaxillary wiring and an external support, such as headcap and rubber bandage or Kingsley type of headgear and splint, may be indicated pending more absolute and permanent fixation.

The principle of splintage with all these fractures is to attach the mobile region to a fixed point by the most rigid method available. Teeth are a big advantage in these fractures. What would the surgeon give if a fractured femur had a whole row of teeth protruding outside the thigh? The best method available for holding these teeth is by metal cap splints, which can be held to the available fixed points by various means. Thus: (i) A unilateral alveolar fracture can be held to the sound side by a continuous single splint. (ii) The transverse alveolar fracture, reduced and moderately mobile, can be fixed to the lower jaw by locked cap splints. If there is tendency to persistence of open bite, elastic traction by rubber bands can be used between the upper and lower splints. (iii) If there is gross mobility of the lower maxilla and any tendency to prolapse into the mouth, the vertex is used as the fixed point and a splint on the upper jaw can be suspended by a Kingsley type of extraoral support, or by direct traction through the cheek with wires

from the splint to metal horns on a plaster headcap (Mowlem[3]). (See Figure X.) Methods of fixation or traction to the vertex require a satisfactory point of resistance in the upper maxillary segment. If comminution and mobility are so great that this point of resistance is not present, an external rigid but adjustable steel bar must be incorporated between plaster headcap and cap splint in the upper jaw. With such a system of fixation there is the obvious advantage of a free mandible, unless concomitant mandibular fracture has also to be managed.

As already noted, the third degree of these frontal violence fractures with cerebro-spinal rhinorrhœa should not be subject to primary manipulation. The most that should be done is that the nasal arch might be gently elevated and the airways established by a rubber tube. One must never be tempted to pack nostrils leaking cerebro-spinal fluid, even as a temporary dressing plug.

FIGURE X. To illustrate method of "through-cheek" maxillary suspension. By using a close and well fitting headcap the skull is used as the fixed point from which to exert traction to the maxilla by wires through the cheek in a straight line from lugs on a metal cap splint on the maxillary teeth to horns incorporated in the headgear. Elastic traction or a turnbuckle can be included in the system.

Early Management of Lateral Violence Fractures.

The Simple Malar Depressions (First Degree).—Early the simple malar depressions can be elevated easily and they stay up. Of various methods, the easiest and most universally effective is elevation from behind, by use of the temporal approach from within the hairline (Gillies[4]). If simple malar elevation is the only indication for operation, a good practice is to proceed with local anæsthesia and supplement this with a few cubic centimetres of "Pentothal" just for the actual disimpaction. The instrument illustrated (see Figure XI) is a Bristow's malar elevator; there are other types of elevator, and the slightly curved handle of any bone forcep type of instrument can always be used with good effect. A short incision about three-quarters of an inch long is made just within the hairline, clear of the temporal artery; the temporal fascia is exposed; it is white and easily recognizable. This is opened in the line of the incision and the blunt instrument is passed down in the plane deep to the fascia and the fatty tissue behind the body of the malar itself—not just the zygomatic arch. By leverage with the instrument the malar is raised. There is always an audible crunch and the finger on the fracture line at the infraorbital ridge checks the reduction. A few sutures are put in the temporal incision.

Other effective methods are described, such as using hooks from in front (Maclure[5]). Though it is easy to bring the malar forward by this method, it does seem in many cases that depressions of the orbital floor are not so easily reduced in this way. With leverage from behind the malar is adequately elevated as well as brought forward, and from the functional point of view it is this downward, rather than the backward, displacement which must be adequately reduced.

There are some who advocate opening of the antrum for correction of malar depressions. This method has certain decided disadvantages and possible complications and should be reserved for two special indications: (i) those second degree malar maxillary depressions, where there is a lot of comminution of the antrum itself and of the orbital floor, so that with

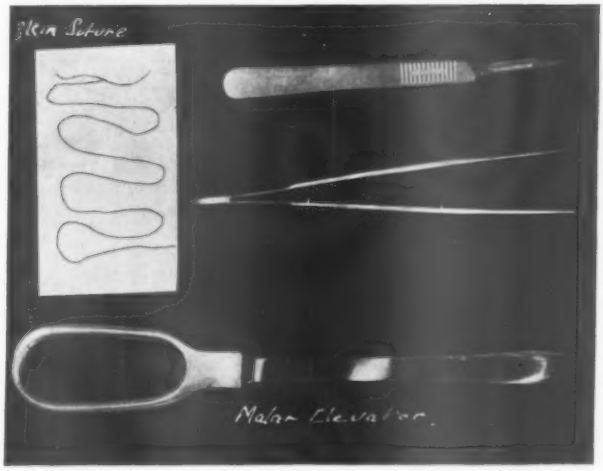

FIGURE XI. Armamentarium for correction of malar depressions by use of the temporal approach (Gillies). The elevator illustrated is a Bristow's malar elevator. Its end is slightly curved and blunt.

elevation of the malar proper it would tend to prolapse again and diplopia would persist; (ii) when the diagnosis has been overlooked or reduction in the critical phase has not been carried out.

The antrum is opened as for a Caldwell-Luc antrostomy, the depressed fragments are ironed out and elevated from within the antrum, and the orbital floor is held up by firm packing of the antrum cavity for about a week. This is a long time; it usually causes some reaction and residual antritis and the oral fistula may take much longer than usual to heal. Flavine and paraffin strip gauze are used for the packing; one end is left at the orifice where it can be held by a plug of gutta percha. We must not regard elevation via the antrum as the method of choice for the early correction of ordinary malar depressions. Blood in the antral cavity is not an indication for antrostomy.

That ends what is regarded as the early management of upper facial injuries. Later treatment is the province of a special unit where all facilities and ancillary aids to treatment are available. Elaborate appliances and detailed treatment may be indicated, but only the principles used are indicated in this paper.

Treatment from the Critical Period of Two Weeks to about Three Months.

Following these injuries there is a phase from the second week after injury to about three months in which manipulation *per se* is not effective

FIGURE XIIA. Typical appearance of a neglected frontal violence fracture, long-standing collapse of middle third of face.

FIGURE XIIB. Result of treatment by post-nasal epithelial inlay graft and a supporting prosthesis attached to a denture.

FIGURE XIII. Casts of the same face. Left: Showing old lateral violence type of fracture with long-standing malunion of comminuted and depressed fracture of the malar maxillary complex. Right: After "camouflage" of the defects by plastic correction and the use of cancellous bone graft from the ilium.

to obtain reduction that is good enough for immediate fixation, but slow traction can do so. Skeletal traction on face bones can be arranged in any direction—downwards, upwards or forwards. This implies a fixed point from which to work. It may be an intact segment of the maxillary alveolus, it may be the mandible, or again we may use the skull via a well fitting plaster headcap. To effect reduction by slow skeletal traction the chief methods used are as follows:

1. From the retroposed middle third of the face or the retroposed alveolar process traction from an upper cap splint by cord across a pulley on a bed frame sometimes gives an amazing advance of the whole maxillary

FIGURE XIV. Old lateral violence type of fracture with fixed malunion of comminuted depressed fracture of right malar maxillary complex. On the left before, on the right after, plastic correction and the use of a cancellous bone graft from the ilium to build up the infraorbital ridge and floor. Note how the right eye, an artificial one, has been raised.

complex. A weight of two pounds acting for about forty-eight hours is the order of traction used; sometimes the result is obtained in only a few hours. When the deformity is corrected, the reduced position is maintained by locking cap splints previously designed and applied to upper and lower jaws.

2. For collapse of the upper part of the face skeletal traction can be arranged by wires through the cheek from an upper cap splint direct to horns incorporated in a plaster headcap. Traction can be varied by a turn buckle between headcap and wire suspension (as in Figure X).

3. When it is necessary to hold displaced lower maxillary segments and there is no intact upper maxillary framework, it may be necessary to reduce and to control the floating fragments by a system of headcap and upper cap splint with a rigid but adjustable bar between. Slow correction can then be effected with screws or a turnbuckle.

4. Elastic traction by rubber bands between upper and lower splints or arch bands and elastic traction across the palate are effective for more simple

and localized fractures. In all cases the principle at this stage of treatment is to use continued traction, graduated or elastic, over a period and then fixation when the optimum reduction is obtained.

For fractures in the malar region in this period correction by opening of the antrum will have to be used more often than with early correction. It may sometimes be necessary to make direct skeletal traction on a floating infraorbital ridge to a projection post from a plaster headcap.

The Remote Treatment of Malunited Face Fractures.

In malunited facial fractures the indications for treatment should be reviewed. Cosmesis should be accepted as an indication only if the deformity is gross. (This will vary with the individual and his walk of life.) With little deformity there are often disturbing symptoms and sometimes psychological disorder is present. Visionary upset must always indicate treatment.

Open reductions are generally hopeless and substitution methods are used. Bone grafts give good results for depressed noses, but a post-nasal epithelial inlay to carry a nasal prosthesis with subsequent bone graft is necessary for the gross "dish face" deformity (see Figures XIIA and XIIB).

For a depressed cheek region a temporal muscle flap turned back over the zygomatic arch, free fat grafts, cartilage grafts or bone grafts all have their particular indications (see Figure XIII). If the eye is absent the indication is entirely cosmetic, but if it is present with any upset of vision, a shaped bone or cartilage graft is used which, as well as building up the infraorbital ridge, has a flange that is inserted subperiostially back over the depressed orbital floor to raise it (see Figure XIV). It may sometimes be necessary to suppress vision on this side, and we see a few cases in which the patient is amblyopic, though he may not know it. All these considerations must be taken into account.

It is not intended to elaborate on the remote management of these injuries or to cloud the issue of the importance of their early recognition and active treatment. There is no place for large numbers of plastic or camouflage surgeons in the 1918 sense, but all services require surgical officers who can appreciate and apply the proper early management of these casualties.

ACKNOWLEDGEMENTS.

I wish to thank the Director-General of Medical Services for permission to submit this paper for publication. The presentation of the subject is based on the teaching of A. H. McIndoe, Consulting Plastic Surgeon to the Royal Air Force.

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Case Reports.

CHONDROMA OF A MENISCUS OF THE KNEE JOINT.[1]

By L. W. Cox,
Dunedin Hospital, Dunedin.

Mrs. S., fifty-four years of age, was admitted to Dunedin Hospital complaining of pain, swelling and stiffness of the right knee of two months' duration.

The story was that the knee first began to swell, then became painful, and as it swelled it became more painful and gradually stiffer. The range of movement also was diminished. By the time of admission the knee was tender to walk on and the gait was disturbed, there being a stiff right leg limp. There was no definite story of trauma nor any other exciting factor.

Examination revealed diffuse fusiform swelling of the right knee. This was limited to the soft periarticular tissues, there being no sign of fluid in the joint cavity. The temperature of the two knees was approximately the same, the right being slightly warmer. Movement was limited, extension being incomplete by 10° and flexion was only 50°. The joint was very painful on movement, active or passive, but there was no crepitus. The following report was received when an X-ray examination was made: "Arthritic changes are present in right knee joint. In the upper surface of the internal condyle of the femur there is a lifting of the periosteum, with rarefaction beneath it. This appearance is suggestive of a tuberculous lesion."

A provisional diagnosis of tuberculous arthritis was made in spite of the patient's age. X-ray examination of the chest revealed a primary complex with calcified hilar glands which seemed to add weight to the diagnosis.

On March 10, 1943, an exploration of the knee joint was undertaken by Mr. J. Renfrew White, F.R.C.S., with a view to (*a*) conservative synovectomy if the disease was in its early stages, (*b*) radical excision of the joint if the disease was advanced. A tourniquet was applied and a vertical mid-patellar incision was made. The patella was split and the joint was opened. Clear watery fluid was present in the joint. A white hyaline mass about the size of a walnut was lying loose in the joint; this was removed. A similar mass was formed from the anterior part of the medial meniscus. The meniscus and mass were removed. Marked osteoarthritic changes in the joint, bony lipping and hypertrophy of synovial fringes were present. One very large fringe was removed.

The wound was closed in layers and a pressure bandage and plaster cast with the knee in extension were applied.

The pathological report was as follows: "The specimen consists of a semilunar cartilage, at one end of which there is a chondromatous growth about half an inch in diameter. There is also a separate portion of tissue apparently derived from the tumour. Sections of the tumour show at the periphery encapsulating layers of dense fibrous connective tissue in which there are small vessels. Lying within the capsule there are irregular islets of cartilaginous tissue separated by bands of fibrous connective tissue. The cartilage cells, where present, are irregular in size and shape and distribution. There is no evidence of the presence of sarcomatous elements. Both portions of the specimen have the same microscopic structure. The appearances are those of a chondroma."

Plaster was removed after twelve days and movements were commenced. The patient was discharged from hospital on April 10, 1943, with 178° extension of the knee and 40° of flexion. The patient attended the physiotherapy out-patient department until July 6, 1943, when extension was 176° and flexion 86°. Movement was free and there was no pain on walking; the gait was normal.

Discussion.

Chondromata usually occur in connexion with growing tissue, most frequently at the ends of long bones in children and in the flat bones. Other unusual sites of origin have been noted—ovary, breast, testis, auricle—but in these cases the growths have all been due to teratomatous formation or misplaced cartilage cell rests. I can find no record of a tumour of a fully differentiated cartilaginous structure such as a semilunar fibro-cartilage. A case of chondroma of the internal meniscus of the knee joint is described.

[1] Accepted for publication on November 15, 1943.

CAROTID BODY TUMOUR (PERITHELIOMA OF THE CAROTID BODY).[1]

By KENNETH W. STARR,
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R. FRANCIS,
Major, Australian Army Medical Corps,
H. HAM,
Major, Australian Army Medical Corps,
AND
J. J. TONGE,
Captain, Australian Army Medical Corps.

(From the Surgical Division of the 113th Australian General Hospital, New South Wales.)

THE rarity of carotid body tumours is well recognized. A recent letter from the Librarian of the Royal Australasian College of Surgeons stated: "I have searched the indices of THE AUSTRALIAN AND NEW ZEALAND JOURNAL OF SURGERY, the *Western Australian Clinical Reports*, the *Royal Melbourne Hospital Clinical Reports* and *The Medical Journal of Australia* back to 1910 and have found only one report of a case of tumour of the carotid body. This was published in *The Medical Journal of Australia* on December 9, 1922, page 666, by Mr. B. T. Edye. In this article the author states: 'In the records of the Royal Prince Alfred Hospital from 1910 there was but one instance until the case I am now reporting was added in February, 1921.' The former case was dated February 19, 1914. There are reports on both cases."

It is considered, therefore, that this case report may be interesting.

CLINICAL HISTORY.

The patient was J.F., a male, aged thirty-two years. There was nothing relevant in his family history.

For nine years he had noticed a swelling enlarging very slowly to about the size of a pigeon's egg under the angle of the left jaw without other symptoms. As it caused no trouble he did not seek medical advice. He was passed as a first-class life by an insurance company and was accepted as Class A (fit for duty with field formations) in November, 1941, with the Australian Imperial Force.

In June, 1942, he was seized with severe pain in the left side of the neck and face, headache, feverishness and sore throat, accompanied by marked increase in size of the swelling in the left side of the neck (to about the size of a duck's egg). His unit medical officer diagnosed the condition as tonsillitis and sinusitis and after two days he was evacuated to hospital for ten days. Inhalations administered for the sinusitis increased the pain. On the seventeenth day he was seen by an ear, nose and throat specialist and referred to 102nd Australian General Hospital for tonsillectomy. After three days in hospital the pain and swelling subsided. After three weeks he was transferred to 113th Australian General Hospital for investigation by a physician.

Part I.

(R. Francis, Visiting Ear, Nose and Throat Specialist.)

The interesting part of this case is the sudden onset with symptoms suggesting inflammatory cause.

This patient was admitted under a physician on July 17, 1942, and transferred to the Ear, Nose and Throat Department on July 20, 1942. The history was of the sudden onset of left cervical pain with a transient sore throat one month previously. On examination there was hyperæmia of the pharyngeal pillars with swelling of the left posterior pillar and gross cervical adenitis on the left side. Needle puncture of this pillar swelling had been carried out two days previously with a negative result. Chemotherapy had no effect, but in twelve days the cervical mass resolved into two discrete

[1] Accepted for publication on May 25, 1943.

swellings and all tenderness had gone. As the tonsils still showed debris, tonsillectomy was carried out on August 3, 1942. Both tonsils were stripped cleanly and sent for pathological examination. Immediately after tonsillectomy the glandular mass increased in size up to its previous maximum.

When the tonsils had healed, the left posterior pillar swelling persisted and the cervical adenitis again resolved into two discrete masses.

In view of the pathological report, this patient was referred to Sydney Hospital for deep X-ray therapy. This course had no effect on either the glands or the posterior pillar mass.

Later, in conjunction with Major Ham, insertion of radon seeds to the pharyngeal mass was carried out on November 12, 1942, without appreciable benefit. The patient was then referred to the surgical department for removal of the cervical mass.

Part II.

(H. Ham, Visiting Radiotherapist.)

I first saw this patient on August 20, 1942, at the request of Major Francis. Tonsillectomy had been performed, and the report by the pathologist was available. In view of the report on the left tonsil, it was considered that irradiation was indicated, and deep X-ray therapy was arranged at Sydney Hospital.

On examination, in addition to the firm circumscribed mass in the upper part of the neck on the left side, there was an elongated smooth swelling in the left posterior faucial pillar and lateral pharyngeal wall of rubbery consistency and extending well below the lower pole of the tonsillar fossa. From August 26, 1942, to September 7, 1942, deep X-ray therapy was given directly to the left upper side of the neck, a dose of 2,700 *r* being administered at 275 kilovolts.

There was no appreciable change in either the cervical or pharyngeal masses following this treatment. It was thus established that the tumour was not of the radio-sensitive variety, and on the evidence of this radiotherapeutic test, it appeared that a diagnosis of either lymphosarcoma or atypical carcinoma could be excluded. The former would show marked regression with a dose of this order and the latter would be expected to show definite diminution.

When the case was reviewed early in November, the further possible methods of treatment appeared to be: (*a*) excision of the pharyngeal tumour or implantation of radon seeds, (*b*) excision of the cervical mass followed by deep X-ray therapy.

It was decided to implant radon seeds into the pharyngeal mass. It was thought possible that a more intense local dose which could be applied in this way might cause regression if the tumour was not completely radio-resistant.

On November 12, 1942, seven gold radon seeds each containing 1·1 millicuries were implanted under intravenous anæsthesia. Three were inserted along the anterior border of the mass, three along the posterior border of the mass, and one in the centre of the mass. No appreciable diminution was noted one month later. The tumour was thus proved to be completely radio-resistant, and further irradiation was not indicated.

In the light of the diagnosis subsequently made, the response to irradiation is not surprising. The radio-resistance of tumours of the carotid body has been mentioned by several writers.

Part III.

(Kenneth W. Starr, Officer Commanding Surgical Division.)

On December 24, 1942, I saw this patient at the request of Major Francis and reported: "There is a fixed mass in the left upper neck which I think is a direct extension, if a malignancy, from the lower tonsillar pole. The failure to disappear after irradiation makes me feel that it should be excised widely. For operation December 28, 1942."

Operation.

Anæsthesia.—Half an hour before operation a hypodermic injection of one-sixth of a grain of morphine sulphate and one one-hundred-and-fiftieth of a grain of atropine sulphate was given. Ether was given by the endotracheal method.

Technique.—The time for the operation was two hours. The position was similar to that adopted for dissection of left submaxillary lymph glands.

Exposure was secured by a curved left submandibular incision from mastoid to submental region. The flaps were dissected upwards for three-quarters of an inch above the mandibular margin and downwards to the middle of the thyreoid cartilage. The previous irradiation and implantation of radon had rendered the operative area tough and fibrous, which, with the great tendency to hæmorrhage, caused some difficulty. The condition was not recognized by me during the operation, but was suggested by Squadron-Leader B. Riley, Royal Australian Air Force, and Major Curzon Furner, Australian Army Medical Corps.

Operative Steps.—The following operative steps were employed:

1. Ligation and division of the left common facial vein immediately below the posterior belly of the digastric muscle.

2. Elevation of the left submaxillary gland by dividing the fascia at the digastric tendon. Ligation and division of the left external maxillary artery.

3. Exposure of the left hypoglossal nerve with its thyreohyoid branch anterior to the tumour and the *descendens hypoglossi posterior.*

4. Division of the posterior belly of the left digastric muscle half an inch posterior to its tendon.

5. Ligation and division of three large veins emerging from the surface of the tumour and entering the left internal jugular vein under the *descendens hypoglossi* nerve.

6. Division of the left superior thyreoid and left lingual arteries at the anterior border of the tumour.

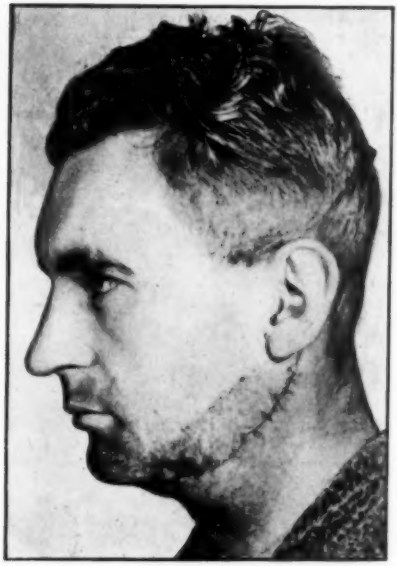

FIGURE IA.

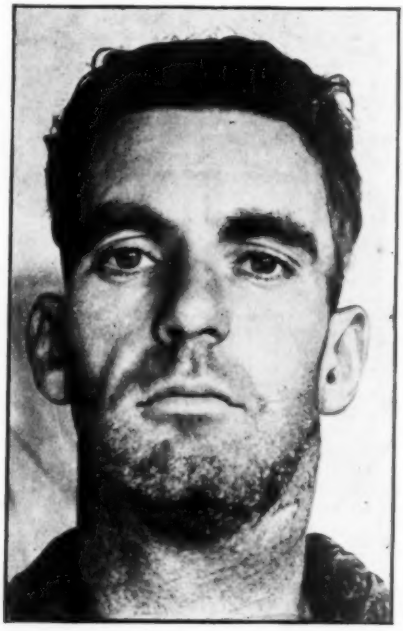

FIGURE IB.

Showing the incision employed.

7. Division of the left external carotid artery between the lingual and superior thyreoid branches.

8. Traction on the lower half of the tumour by inserting about eight silk sutures into the capsule, thus enabling the tumour to be elevated from the pharyngeal wall.

9. Blunt dissection of left superior laryngeal and glosso-pharyngeal nerves from the deep surface of the tumour. Ligation of very numerous bleeding veins in the pharyngeal venous plexus. Ligation of the ascending pharyngeal artery, which was injured on the deep surface of the tumour above the superior laryngeal nerve.

10. Careful dissection from the lower left tonsillar pillar. The tumour then only remained attached to the left internal carotid artery, whence it was very carefully dissected with small blunt dissecting scissors by gradually separating the artery from the almost enveloping tumour. A thinned, but intact, arterial wall remained.

11. The residual cavity with the pharyngeal wall and associated structures medially, the carotid sheath posteriorly, and partly closed superficially by the internal pterygoid and submaxillary gland above, was packed with fine ribbon gauze brought out through the centre of the wound. The digastric muscle was sutured and the wound closed in two layers, with tube drainage posteriorly.

Post-Operative Course.

The gauze was removed in two stages, on the second and third days. Discharge from the sinus was free, purulent and persisted for fourteen days. There was no drainage from the posterior tube. The wound otherwise healed and the patient was discharged on the tenth day to a convalescent home and returned to duty in the fifth week.

Comment.

Diagnosis.—The difficulty of pre-operative diagnosis is well known. The criteria commonly accepted are:

1. A painless, slow-growing tumour situated at the carotid notch, present for years (average six years) before operation, in a patient of any age, but commonly the seventh decade.

2. A tumour, ovoid, firm, elastic, compressible, deep seated (never attached to the skin), and movable laterally but not vertically.

3. Diminution in the size of the tumour caused by proximal carotid compression.

The previous irradiation of this tumour considerably clouded the physical characters. It was not compressible. However, the following features were particularly memorable. With one finger of the left hand against the lower left tonsillar pillar and the right hand palpating the tumour from the neck (*a*) there was a definite slight

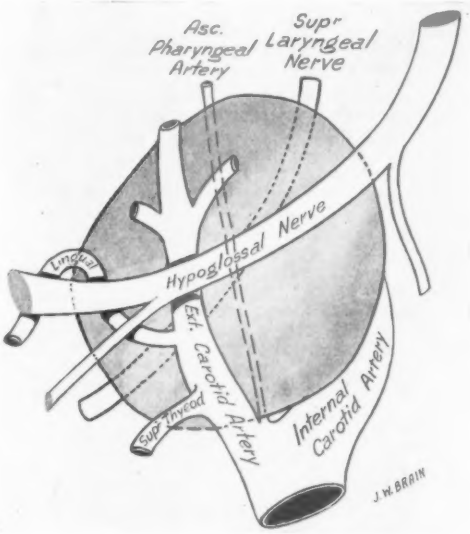

FIGURE IIA. The superficial and deep relations (diagrammatic) of the tumour.

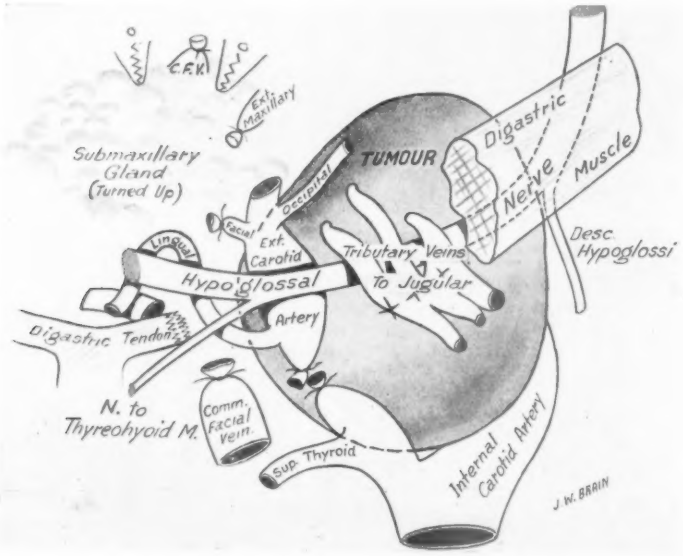

FIGURE IIB. The superficial relations of the tumour, showing the vessels ligated to effect its removal.

bimanual horizontal mobility, (*b*) the tumour was of "rubbery" consistency like a fibro-adenoma of the breast.

Pathology.—The relation to the carotid bifurcation and vessels, the extreme vascularity and the fleshy texture and consistency are the important macroscopic findings. The characteristic microscopic picture of perithelioma is well illustrated in this case (see Part IV).

More recent reviews of the pathology of this tumour emphasize the erroneous optimism with which they were previously regarded from the point of view of malignancy; Harrington, Clagett and Dockerty (*Annals of Surgery*, November, 1941) now estimate that 50% of these tumours are malignant.

Management.—The most recent conclusions regarding the principles of management are summarized herewith:

1. The ideal treatment is complete surgical removal without carotid ligation. Bevan and McCarthy recommended that if the diagnosis was made at operation, the wound should be closed and radiotherapy employed subsequently. However, most of these tumours are completely radio-resistant (Phelps, Case and Snyder). Harrington *et alii* opine that: "It is necessary to remove the tumour completely even if it requires sacrifice of the carotid vessels to control the bleeding from these very vascular tumours. Complete removal is indicated because in our experience all such lesions have been either malignant or potentially malignant. They rarely recur or metastasise after complete removal."

The admonition of Gordon-Taylor should be sounded again: "The main purpose of the communication is to plead once more for caution before undertaking the resection of the cartotid bifurcation for carotid tumour and to impress upon operators that even when the arteries appear almost embedded in the growth, meticulous care and painstaking dissection may sometimes reveal a 'white line' whereby the continuity of the main arterial vessels may remain undisturbed or at least structurally inviolate."

The "white line" was certainly a feature of the operation in this case, and enabled the internal carotid artery to be preserved.

2. The operative mortality is variously given as 25% or higher. Almost all deaths were associated with carotid ligation, resulting in cerebral softening or hemiplegia. The average age of those dying was fifty-three years; the average age of those surviving was thirty-one years; in 50% of cases carotid ligation is necessary.

"The part played by the different nerves of the carotid sinus in the regulation of the blood pressure may possibly be of physiological interest, but to the operating surgeon is of little significance and a mere academic chimera and phantasy which he may disregard lightheartedly" (Gordon-Taylor).

3. The following structures are frequently involved in the tumour: vessels—carotid vessels and the first three branches of the external carotid artery, internal jugular vein; nerves—vagus and recurrent laryngeal, cervical, sympathetic, hypoglossal, glosso-pharyngeal and superior laryngeal nerves.

4. If a pre-operative diagnosis is made, proper systematic proximal carotid compression against the transverse process of the sixth cervical vertebra should be made several times daily for six weeks before operation. The period of compression must be gradually increased until long periods can be tolerated without symptoms.

5. Malignancy may be diagnosed only on microscopic examination. However, the duration of the tumour, the frequency of carotid ligation and the mortality rate are irrespective of malignancy and occur in the benign tumours with equal frequency.

Part IV.

(J. J. Tonge, Resident Pathologist.)

First Specimen.

On August 3, 1942, a piece of tissue resembling tonsil 3·5 by 1·5 centimetres was received for examination. It was somewhat greyish-white in colour, firm to the touch, and on section there was a uniform appearance about the tissue. Macroscopically there was no evidence of newgrowth. It was recorded that at this time a tumour still existed adjacent to the tonsil just removed for examination.

Microscopic Examination.—There was an increase in fibrous tissue and also slight increase in the endothelial cells, but the outstanding feature was the presence of patches of abnormal foreign cells. These cells were variable in size, but were mostly larger than normal endothelial cells, polyhedral or oval in shape. The cytoplasm was pale and granular, the nuclei small, and they did not take the stain as well as usual. Many of these cells showed mitotic figures and they seemed to be destroying the normal tonsil tissue. The cells did not suggest a primary growth, as patches of them were separated by normal tonsillar tissue. It was suggested that they must be metastases from some tumour, probably of the nature of a mixed cell sarcoma.

The sections were sent to the Kanematsu Institute of Pathology, Sydney Hospital, for a review and Dr. Canny in his report suggested the possibility of these cells being

part of "a reactive hyperplasia of the follicular structures, probably the result of recent inflammatory changes". Reticulum staining, however, did not show any gross abnormality of the reticular structure.

In view of the rarity of metastases in tonsils and the mixed nature of the cells, it was difficult at that stage to make a definite diagnosis.

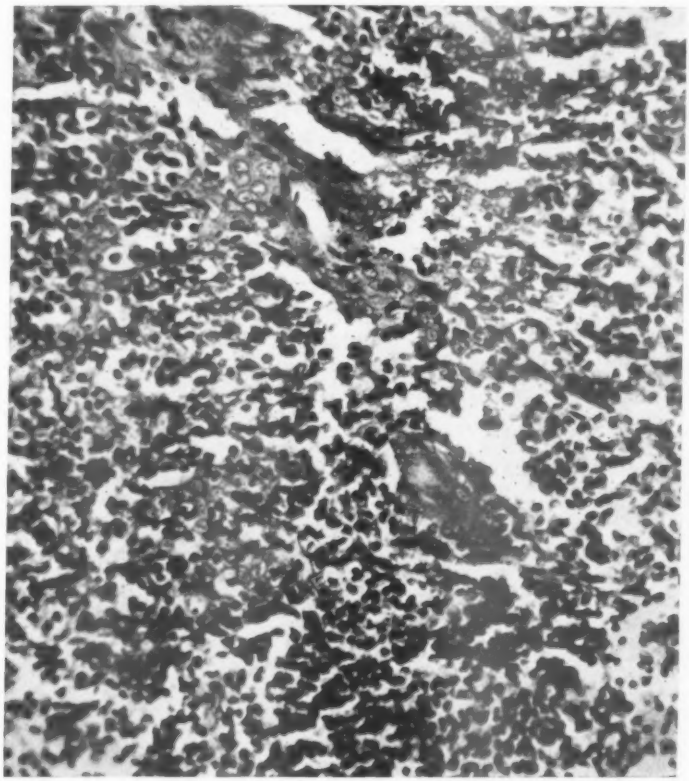

FIGURE III. Section of the left tonsil examined on August 3, 1942 (magnification x 300). The picture shows clearly patches of foreign cells which appear to be invading the normal tonsil tissue. The pale granular cytoplasm of these cells can be seen, and in some mitotic figures can be seen.

Second Specimen.

On January 1, 1943, a piece of tissue was received from the same patient, oval in shape, 5·0 by 4·0 centimetres, reddish-brown in colour, and encapsulated. On section there were numerous yellowish areas visible.

Microscopic Examination.—The structure of the tumour was variable—in parts the cells were collected in closely packed rounded masses, somewhat resembling large human glomeruli. Many of these masses of cells were demarcated from surrounding tissue by one or more layers of flattened cells, which represent a vascular endothelium lining a vascular space. In parts these vascular spaces appeared to surround the cell mass. In some places the tumour had a cavernous appearance with blood spaces separated from one another by endothelium alone.

The cells comprising the tumour masses themselves were very variable in size and shape, some even having a syncytial appearance with prolongation of protoplasm. The cytoplasm of the cells was faintly staining and granular. The granules were not closely set and in some cells vacuolation could be seen. The nuclei stained poorly and were small in comparison with the cytoplasm. Mitotic figures were extremely numerous.

In some parts of the tumour the masses of cells had a more alveolar arrangement and in other areas appeared as whorls. The matrix of the tumour was in the main hyalin. The growth itself was surrounded with a dense fibrous capsule from which strands of hyaline fibrous tissue penetrated the growth. In many areas these strands and the capsule itself appeared to have been invaded by tumour cells.

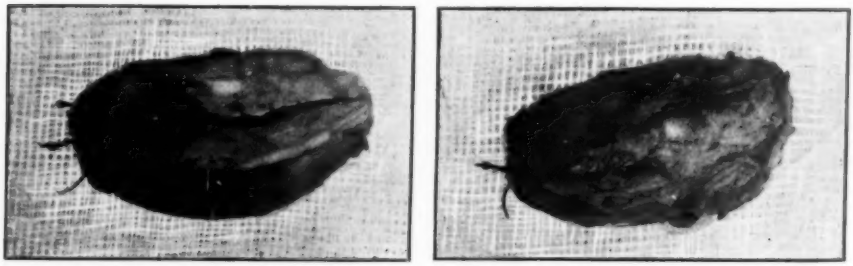

FIGURE IVA. FIGURE IVB.

The macroscopic tumour, natural size. The carotid groove is well shown.

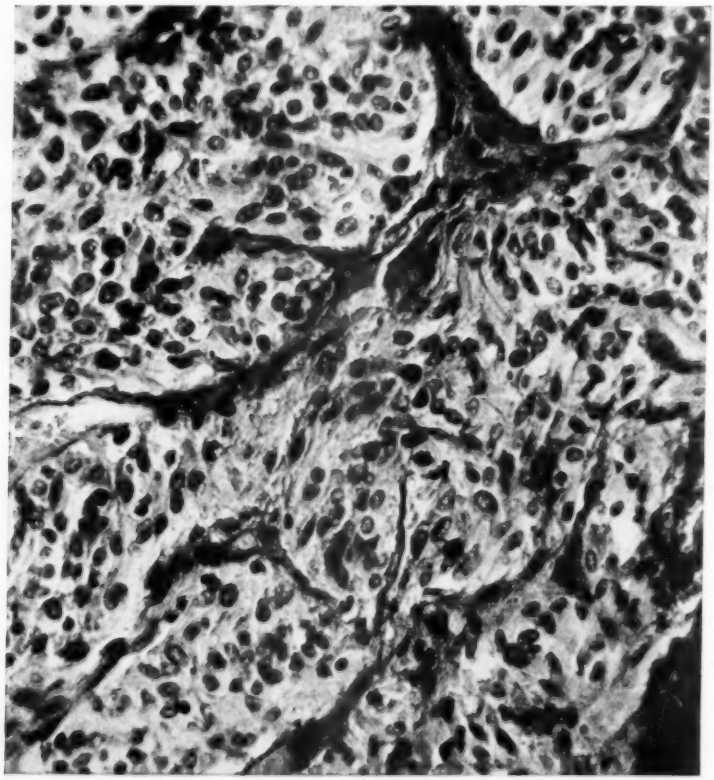

FIGURE V. Section of carotid body tumour, examined January 1, 1943 (magnification × 300). The "glomerulus" arrangement of the tumour is seen in this photograph. The cells are seen to be variable in shape and size with pale granular cytoplasm. In some cells vacuoles can be seen. The similarity between these cells and those "foreign" cells in Figure III will be seen.

The picture is that of a perithelioma of the carotid body, and it is a good example of the "alveolar" or "insular" histological pattern described by several writers. It is usually considered that 80% of these tumours are benign, but Harrington *et alii* prefer to regard all carotid body tumours as being malignant or potentially so. This growth was considered as undergoing definite invasive and malignant changes; the reasons are: (*a*) the definite evidence of invasion of the capsule, (*b*) the abundant mitotic figures in the tumour cells and (*c*) the variability in size of these cells.

These tumours are slow growing, occupying years. At the same time Keen and Funke divided the malignant tumours into two classes: those running a benign course in early stages and those showing a marked tendency to malignancy. In several reported cases the vessel walls have been invaded, and Keen, Flopfenstein and Kretschmer report cases with involvement of regional lymphatic glands. Gifford reports metastases in the liver, and in Monckeberg's case metastases were found in the ovary four years after removal of the primary growth. Harrington, Clagett and Dockerty mention two patients who died of questionable cerebral metastases, and a further two with definite local recurrence of the growth.

In view of this second tumour received from the patient and its close apposition to the tonsil, already removed, it is reasonable to suppose that the unidentifiable cells found in the tonsil were cells from the carotid body tumour, being identical in type, which had spread and invaded locally.

ACKNOWLEDGEMENTS.

Our thanks are due to the Director-General of Medical Services for permission to publish this report, to the Librarian, Gordon Craig Library, Royal Australasian College of Surgeons, for her ready and invaluable assistance and the preparation of the bibliography. Sergeant Brain, of Number 1 Plastic Unit, has provided the drawings and macroscopic photographs, and Mr. Woodward Smith, of University of Sydney, the photographs of the microscopic sections.

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SHATTERING GUNSHOT WOUND OF THE ELBOW.[1]

By JOHN DEVINE,
Major, Australian Army Medical Corps, Australian Imperial Force.

THE following case is picked out for presentation to show that, with modern chemotherapeutic aid and rehabilitative treatment, most desperate limb injuries will often yield a limb of at least more functional use than an artificial one; and that more than ever can modern immediate war surgery be conservative.

B., aged twenty-seven years, came under my care in the Tobruk Hospital one and a half years ago. He had been wounded on the left elbow by an anti-tank shell. His elbow was a pulpy mass, and his forearm dangled from his arm by bridges of soft tissue antero-laterally. Three to four inches of the upper ends of his radius and ulna were missing, along with his ulnar nerve. The wound was blackened and soiled. Though he had lost much blood, his general condition was surprisingly good.

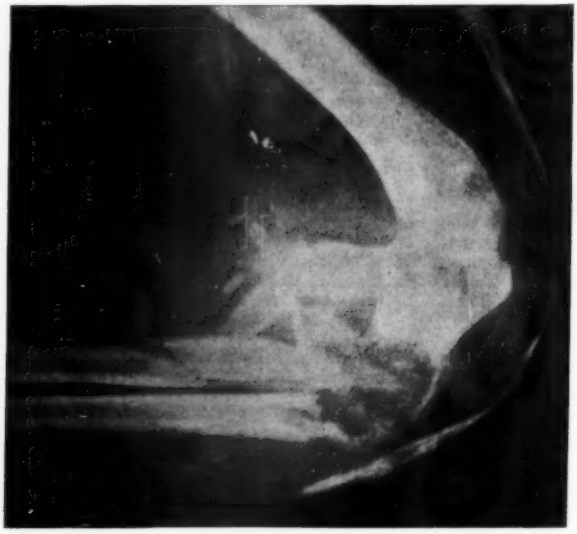

FIGURE I. Radiograph taken eleven weeks after the patient was wounded.

Under "Pentothal" intravenous anæsthesia the wound was subjected to *débridement* and the skin edges were excised, the wound was covered with sulphanilamide powder and "Vaseline" gauze, and the whole limb from shoulder to hand was encased in a complete plaster.

After operation four grammes of sulphanilamide were administered daily for some days. Several days after the operation, pain and swelling of the hand necessitated removal and replacement of the plaster, which was done with the arm at an angle of about 130° of flexion and slight pronation. This angle was chosen because the patient said that in the event of the hoped-for ankylosis occurring, this position would be the most advantageous position for him in his clerical occupation. Following this he had no further trouble, and about a week later elected to take his place as a walking patient in order to be evacuated from the area by sea.

He was returned to Australia, and on the trip home he had the usual low-grade infection of his wound and had his plaster renewed once.

[1] Accepted for publication on February 16, 1943.

His first radiograph after his arrival in Australia, taken eleven weeks after he was wounded, is shown in Figure I.

His arm was kept immobilized in plaster, and six months after he had been wounded he had progressing union between the various fragments and was having active movements. At about this time a small discharging sinus which had persisted on the upper and medial aspect of the forearm, had finally healed. Tinel's sign was present as far down the ulnar nerve as one and a half inches proximal to the head of the ulna, but it was considered that even if complete nerve regeneration did occur the state of the

FIGURE II. Elbow one and a half years after wounding.

FIGURE III. Hand as it is today.

muscles and joints would not allow of improvement of function. He had three to four inches of shortening of the left arm.

Ten months after he had been wounded he commenced clerical work in a base headquarters.

Now, one and a half years after his wounding, he performs his everyday tasks such as shaving and dressing *et cetera* without assistance, and can hold a matchbox in his left hand. He has continued his clerical work, and has been promoted. The present state of his arm and hand is shown in Figures II and III.

Acknowledgements.

I wish to thank Colonel Sherwin for permission to publish this case, and Professor Sunderland for the use of the photograph for Figure III.

Surgery in Other Countries.

[In this column will be published short résumés of articles likely to be of practical value from Journals published in other countries and not readily accessible to surgeons in Australia and New Zealand.]

PENETRATING GUNSHOT WOUNDS OF THE HEART.

F. Sauerbruch (Berlin): *"Steckgeschosse in Herz und Lung", Deutsche Zeitschrift für Chirurgie*, Volume cclv, October, 1941.

THIS article is based almost entirely on Sauerbruch's personal experience, and the greater part of it is concerned with heart wounds. The term penetrating wounds of the heart is used throughout the paper in its full clinical sense of interference with the heart action owing to lodging of a missile in any situation in which it can exercise an irritative effect on the plexus of cardiac nerves, rather than in the anatomical sense limiting it to penetration of the heart wall. These irritative effects produce arrhythmia, tachycardia and fibrillation as immediate results, and slowing of the pulse, lowering of the blood pressure, cardiac pains and cramps may ensue.

A case illustrative of this point is that of a major wounded in the war of 1914-1918, whose first complaint of pain was made while he was a prisoner of war in France. Serious anginal attacks resulted in his transfer to Switzerland. He had been a particularly active athletic man before the war, and had stood the fatigues of campaigning well until wounded in the left upper part of the chest wall by a small shell splinter. His first symptoms were slight temporary spitting of blood for two days only and a severe stabbing pain, which, however, soon passed. A little later severe pain set in, radiating down the left arm, and after prolonged observation and numerous investigations it was decided that the cause of this pain was a small shell fragment which was visible with X rays. In accordance with the patient's urgent desire, removal of this was attempted. When the pericardium was exposed a whitish area the size of a penny was seen on its surface in front of the aorta. When this area was palpated, a typical attack of "angina" was experienced, and after this had subsided the scar tissue was incised and the fragment removed. Complete freedom from all symptoms followed the operation, and it is undoubted that the presence of the foreign body must have been the cause of them, and that it acted by reflex spasm on any such movement as deep breathing or so forth; but it is not clear whether this spasm occurred in the aorta or in the coronary arteries. The point of the illustration lies in the effect on the heart action of a foreign body lying actually outside the heart confines.

A second patient with a missile in the upper posterior mediastinum was similarly relieved by its removal. His complaint was severe and permanent cardiac arrhythmia, dating from the injury. In this case the bullet lay outside the pericardium, on its upper posterior right fold, and one may assume that the effective mechanism was irritation of the vago-sympathetic plexus.

Mechanical effects from such a missile were well illustrated in the case of a soldier who, during the Polish campaign of the present war, received a bullet in the medial side of the lingula of the left lung. It caused him to suffer irregularity of the heart action, a feeling of cramp, and inability to endure effort. The clinical opinion was formed that this effect was of cardiac origin, owing to the scarred lung having formed adhesions to the left auricle. At the subsequent operation this opinion was confirmed. A thick mass of scar tissue was found, enclosing the foreign body and adherent, through the pericardium, to the left auricle. The lung was pulled on at each systole and the heart drawn over with each deep breath. Removal of the offending foreign body resulted in cure of the symptoms.

From these cases it is clear that the operative removal of foreign bodies which produce these ill effects on the heart action has a great deal to offer the patient for his comfort and well-being. None the less, the decision to operate must be made only after very careful study of the indications. Only when repeated investigations have been carried out, and prolonged observation has made it certain that the foreign body is actually the cause responsible for the symptoms, should the decision to remove it be made. The mental anxiety caused by the knowledge that a potentially dangerous foreign body lies close to so vital an organ as the heart can of itself cause ill effects which need no surgery for their removal.

Wounds actually penetrating the pericardium present their own problems. Blood and exudate in the pericardial cavity do not of themselves require operation, repeated aspirations usually sufficing. But should these suppurate, then early surgical drainage is called for.

Should the heart itself be involved, the indications are clearer. The pain or the alteration in the heart's action is easily associated with the anatomical findings. But the caution must be given that these wounds do not lead necessarily to a fatal ending. Steffens, in a comprehensive work, has shown that of 109 subjects bearing foreign bodies actually in their hearts, 95% showed in the early stages very few subjective symptoms. Later the picture altered, and only 13% remained symptomless. All the other 87% complained of palpitations, shortness of breath, anginal pains or chest pains, occurring when they lay on their sides. Strebel holds that of all patients who have foreign bodies lodged in the heart, 60% must later expect some permanent interference with normal health. In Sauerbruch's opinion these figures are too high, but he agrees that with the passage of time the number of patients showing symptoms will increase.

The value of an electrocardiographic record is not clear. Some observers (notably Alvarez and Sburlatti) have recorded electrocardiographic changes ranging up to complete heart block in their cases. In many instances, however, the tracing has failed to give any help. Where it is of assistance, its value in estimating the condition anatomically and in forecasting the probable value of operative interference is great. An interesting example of this is quoted by Sauerbruch from the work of Ugon, who made electrographic records of a patient during the operation for removal of a foreign body from the posterior wall of the left ventricle. Palpation of it caused extrasystoles; traction on it produced tachycardia with conduction interruption; and when it was actually being withdrawn the heart passed into ventricular fibrillation. It must always be remembered, however, that fragments even lying within the heart cavities may rest there and produce no interference with its action; and this even more so when they are encapsulated within its walls, and any operative attack in such cases must therefore be undertaken only after very grave consideration. When, however, the fragment happens to lodge in some special area of the heart, the position may be quite different, and its effect on nervous conduction or the flow of blood, by its bodily presence or by the scar tissue formed round it, may make operation imperative. The following illustrative case, first reported by Sauerbruch in 1925, is again set forth.

From a healthy man of forty-six years a rifle bullet was removed from an encapsulated mass of scar tissue lying close against the right pulmonary root. The region of the right auricle and the upper lobar branch of the pulmonary artery were laid bare by the dissection. The abscess cavity from which the bullet was withdrawn lay on the lung surface and in close association with a bronchus, and had to be packed, the packing impinging on the space between the heart and the mediastinal surface of the lung. The patient's condition was good, but his pulse rate rose to 180 per minute and an arrhythmia followed which was unresponsive to quinidine. On the packing being removed an immediate improvement in both rate and rhythm occurred, but as soon as the cavity was repacked both tachycardia and arrhythmia reappeared. Finally only a light strip of gauze was left in the cavity and there was no further difficulty. It is evident that a foreign body may exercise the same pressure effect on the atrio-ventricular region and disturb the heart rhythm, and this particularly so if it happens to affect the zone between the superior *vena cava*, the sinus and the right auricle, the neighbourhood of the atrio-ventricular septum or the upper part of the interventricular septum.

Next in importance to a clear knowledge of the actual condition existing an accurate estimation of the risks of operating is essential. Any surgical procedure on the heart itself carries dangers, such as sudden cessation of the heart beat, as well as possibly uncontrollable bleeding, and for the post-operative period thrombosis and pericarditis must be borne in mind as possible perils. Pneumothorax must be considered a possible complication. In some cases, of course, the anatomical position of the missile itself may render the attempt to remove it too dangerous to be undertaken. Bird summarized the position by saying that the operation must hold fewer dangers than the foreign body causes or is likely to cause. Only a few surgeons advocate removal in all cases, some of these on the grounds of the likelihood of the missile wandering, though this has not occurred in Sauerbruch's experience. On the other hand, he reports on three soldiers with foreign bodies in their hearts who, conservatively treated, were all back on active service in a few months. Two others, he states, are still under observation. If immediate action is forced on the surgeon by hæmorrhage, arrest of the hæmorrhage is the primary consideration. If the missile can be removed also, so much the better; but it may well be safer to leave it for a later attempt under more favourable conditions.

One of Sauerbruch's recent cases presents points of interest, and is set out on these lines. A forty-two-year-old reserve officer was wounded by shell splinter in the Polish campaign. His immediate symptoms were pulmonary hæmorrhage and an exudative pericarditis. After repeated aspiration of the pleura and pericardium, he recovered and was sent back to duty. He found, however, that on running or long marches he was very short of breath, and developed a cramped feeling. His complaints were at first not taken seriously, until on one long march he became evidently ill with dyspnœa, cramp

and cardiac pain radiating down the left arm, when it was recognized that he had suffered a serious myocardial lesion. Similar attacks followed on several occasions, and œdema of the feet supervened, whereupon he was transferred to Sauerbruch's clinic in Berlin. A long period then elapsed during which numerous investigations were carried out, until it was quite clear that the origin of the symptoms was a small splinter of shell which could be seen by X rays. Operation was then undertaken, and a thick swelling in the left side of the pericardium was discovered. There were several adhesions between the pericardium and the heart in the neighbourhood of the left auricle. The splinter was located with the aid of the Siemen's seeker and was exposed lying in the heart wall. After placing controlling sutures to guard against hæmorrhage, the splinter was safely withdrawn from the auricular wall, which it had penetrated. The immediate post-operative reaction was grave, but settled down. The patient was out of bed in six weeks, and three months after the operation his electrocardiogram was normal and he was returned to duty, where as section commander in a Panzer unit he was able to withstand the rigours of the Russian campaign.

The paper concludes with a few general remarks on technique, particularly stressing that all operations are carried out under local or regional analgesia if possible.

ARTHUR E. BROWN.

THE TREATMENT OF GUNSHOT WOUNDS OF THE ABDOMEN.

Karl Schroeder (Hamm): *"Zur Behandlung der Bauchschüsse"*, *Der Chirurg*, Volume xiv, September 1, 1942.

THE high mortality of abdominal wounds in the last war fell from 80%-90% to 50%-60% following the introduction of early surgical treatment, but these figures relate only to those patients who came within the reach of competent surgeons. On the whole, the recovery rate for these injuries must be taken as being not more than 20% to 25%.

The primary necessity is operation within twelve hours of being wounded. The army surgeon must therefore arrange for the admission of the wounded man as soon as possible to a field or general hospital, these being the only places where the equipment and personnel necessary for the proper treatment of abdominal wounds can be found. The farther back behind the battle line the patient can be treated, the better is his chance of receiving the needful post-operative rest and care. For this reason the base hospital in the home areas is best of all, and swift communication and transport now render this a possibility.

Schroeder reports the case of a non-commissioned officer in the *Luftwaffe* who received a severe abdominal wound over Rotterdam in the first days of the invasion of Holland. By means of radio communication and plane transport he was admitted to the hospital at Hamm two hours after he was wounded, and blood transfusion and operation under "Evipan"-ether anæsthesia were started simultaneously shortly afterwards. The peritoneal cavity contained much free blood and balls of fæces. There was active bleeding from the descending mesocolon, a massive effusion had occurred into the omentum, and many perforations of the small and large bowel together with a laceration of the lower liver edge were present. The bleeding vessel in the mesocolon was under-run, the liver edge was sutured, and the bowel perforations were dealt with. Four hundred cubic centimetres of blood were given during the operation, and continuous intravenous saline infusion was carried out after it. Except for a residual pelvic abscess, the patient's convalescence was uneventful. Schroeder points out that this man owes his life to radio communication and swift plane transport to a base hospital.

ARTHUR E. BROWN.

Reviews.

Pictorial Handbook of Fracture Treatment. By EDWARD L. COMPERE, M.D., F.A.C.S., and SAM. W. BANKS, M.D.; 1943. Chicago: The Year Book Publishers, Incorporated. 8″ × 5½″, pp. 351, with 171 illustrations. Price: 30s.

THIS book is a clear, concise and common-sense pictorial summary of the modern treatment of fractures. It is illustrated copiously by clear line black and white drawings, a drawing being used to illustrate every important step in the technique of treatment. In most cases a single simple method of treating each particular type of fracture is described, and it is only occasionally that the authors slip off into the realm of gadgets in which the general practitioner, for whom the book is written, would be unable to follow.

The book is arranged in two main parts. In the first part fractures are considered generally. In this section some very useful diagrams illustrate the places in the body where skeletal traction may be applied; how to apply plaster casts; the areas which should be protected by padding under plaster casts; methods of treating delayed and non-union by bone grafts and plates; methods of emergency splinting. Some may find fault with the statement in this section that secondary shock is due to loss of blood by hæmorrhage, but most will approve the great stress that is laid on the dangers of the use of a tourniquet, and on the statement that active movements are essential in after-care, being more effective than baths, lights and other passive procedures.

The second part consists of a discussion of fractures of particular regions. Again clear semidiagrammatic line drawings are used to demonstrate the types of violence and the types of fractures which result, and their methods of treatment. Much useful detail is given concerning the actual detail of manufacture of the plaster casts to be employed. Such modern means of immobilization as Roger Anderson pins and bars are well described and appraised as being a good method of treatment, but one that should, because of greater risk to the patient, be employed only by those specially trained in the art. Fractures and dislocations of the hand are particularly well discussed, and stress is laid on the immobilization of only the injured fingers and on active and not passive movements of the uninjured fingers. The chapter on fractures of the facial bones is very brief and a little disappointing.

This book, because of its clarity, common sense and compact size, will be of great use to graduates and students alike. It is well printed, and the diagrams are well produced.

Pye's Surgical Handicraft: A Manual of Surgical Manipulations, Minor Surgery and Other Matters Connected with the Work of Surgical Dressers, House Surgeons and Practitioners. Edited by HAMILTON BAILEY, F.R.C.S. (England); Thirteenth Edition; 1942. Bristol: John Wright and Sons Limited. 8¾″ × 5¾″, pp. 544, with 534 illustrations. Price: 25s. net.

THE thirteenth edition of "Pye's Surgical Handicraft" carries on the excellent work of its predecessor, with the addition of fifty new illustrations and four new chapters on wound healing, renal function tests, administration of serum, and operations on tonsils, harelip and cleft palate. In spite of these additions, there is a reduction in size of the volume due to a reduction in the margin.

This book would seem an absolute essential to all students and house surgeons, as the practical information it contains is not available in the ordinary textbook.

The Australian Army Medical Services in the War of 1914-1918. By COLONEL A. G. BUTLER, D.S.O., V.D., B.A., M.B., Ch.B.; Volume III; 1943. Canberra: Australian War Memorial. 8½″ × 5½″, pp. 1,118, with 85 illustrations, graphs and diagrams. Price: 21s. net.

As the author states in the preface in Volume I and Volume II, the problems were discussed as they evolved in the course of military events—the work was, in short, as planned, a history of the medical problems of the Australian Imperial Force. Those volumes were acclaimed by all who served in the Australian Army Medical Corps, had its interest at heart and appreciated what had been accomplished. What was achieved there entitles the author to a niche amongst the immortals. Volume III ensures that recognition. Here the author is revealed at his best, not merely as the historian, *littérateur* and student of medicine, but as the philosopher with a real appreciation of mass psychology and of the virtues and frailties of his fellow men, be they comrades in arms or enemies. It is a long retrospect to the surprises, problems and epics of 1915. These present the same difficulties and dangers today. It is Britain's tradition that the occasion finds the men.

Chapters 1, 2 and 3, dealing with some technical problems, moral and mental disorders and venereal disease, contain inspirations not only for officers of the Australian Army Medical Corps, but for all who aspire to be successful as leaders of men. The opening chapter, "Chemical Warfare", reveals the real soldier, placing the psychological effect of the element of surprise in correct military perspective. The short appreciation of the reaction of the Canadian troops to the gas attack at Ypres is eloquence indeed; one fact is certain, they would wish nothing more. The effect of the uncertain or unknown in mass psychology and the manner in which it can be exploited by a cunning enemy are well demonstrated in the survey of the use of gas by the Germans: "The surprise of chlorine gave place to the mysterious effects of phosgene and then to the insidious but inexorable onset of the Yperite burn". The Germans had voted themselves a freedom from any moral obligation and had a huge chemical organization in readiness. The British suffered from the Army's traditional undervaluation of

scientific men and methods. Chapter 2 will be considered by many the highlight of the book. An analysis of conduct disorders from the point of view of military behaviour and the relative importance of free will are the opening shots in a scholarly dissertation.

The stress laid on the importance of training, discipline and purposefully ordered habitation in improving the moral fibre might be brought to the notice of many who considered the Australian a ready-made soldier because of his initiative. There is no question the Australian is a good soldier and has initiative; nevertheless, the above-mentioned fallacy was exploded last war and reexploded this. Will it be ever thus for the sake of political expediency? Malingering and the problem of self-inflicted wounds are brought to the light of day. It is surprising to read that no Australian statistics on these problems have been compiled. It is anomalous that this volume should appear in the middle of the second world war in which moral and mental disorders and the problem of venereal disease are still outstanding factors for the Army Medical Corps and the Army. The calm survey of the problem as it existed in 1914-1918, what General Howse attempted and in part accomplished, is clearly set out. The author's knowledge of mass psychology and of the frailties of his fellow men allows him to indicate the difficulties and explain the failure.

There is much in the history of the influenza pandemic that will interest those who have a more enlightened outlook today; but let us remember that the historical approach is the correct one. Those who know the history of diseases know more than the treatment of the present-day malady. It may well be said that in war-time pathology, bacteriology and parasitology come into their own. How true that was for Australia is set out in the author's discussion of the scientific background.

Here also is told the story of the frustration of the research worker in the regular army, of the invasion of the civilians, of the advent of the psychiatrist as distinct from the neurologist, of the birth of military orthopædics, plastic surgery and of the role of the cardiologist and "D.A.H."

Surgeons will read with interest how the problems which concern them today were managed then. The treatment of facio-maxillary injuries, of head injuries, of injuries of peripheral nerves are described in detail by those who had an extensive experience in the management of these injuries. In some cases methods have been modified, in others little advance has been achieved. We are still far from that standardization of technique and methods of treatment that the technician visualizes and the clinician knows will never be. The problem of amputations and artificial replacements and of chronic osteomyelitis and its consequences were then, as they are today, part of the unavoidable aftermath of war. It is in these cases that rehabilitation is so essential and rehabilitation seems always to get away to a bad start.

The syllabus of study for a conference of war medicine and surgery in 1917 might well be that for one today.

Volume III brings to an end a work to which the author has given his all. The Australian Army Medical Corps has indeed been fortunate in its historian.

Transurethral Prostatectomy. By REED M. NESBIT, M.D., F.A.C.S.; 1943. Springfield, Illinois: Charles C. Thomas. London: Baillière, Tindall and Cox. 9¾″ × 6¼″, pp. 201, with 62 plates. Price: $7.50.

A SURGICAL monograph of first importance is a work on transurethral prostatectomy by Dr. Reed Nesbit, Associate Professor of Surgery in the University of Michigan. This book contains technique, methods, procedures, practices in transurethral prostatectomy which the author has found clinically satisfactory. It begins with a chapter in which are described arterial distribution in the normal prostate gland, the changes that occur when hypertrophy takes place, and the bearing these changes have on the technique of transurethral prostatic resection.

Methods of anæsthesia are described. Low spinal and intravenous methods of anæsthesia are recommended. Considerable attention is paid to pre-operative management. The section on the technique of transurethral prostatectomy is a feature of the work. Here is described in great detail, with a wealth of fine illustrations by Didusch, the principles and the technique which the author, in his wide experience, has found satisfactory. To those who are specially interested in transurethral prostatectomy these descriptions will have a special interest and value. The author points out the advantages of transurethral prostatectomy—"freedom from discomfort and sepsis; from drainage wounds; brief confinement to bed; re-establishment of comfortable and continent urinary function on the third post-operative day; discharge from hospital within two weeks". Among the last thousand patients operated on in the University Hospital of Michigan, the mortality rate was 2·1%.

The work has a bibliography of forty-three pages. It is well produced and is a valuable addition to the literature on transurethral prostatectomy.

The Medical Annual: A Year Book of Treatment and Practitioner's Index. Edited by SIR HENRY TIDY, K.B.E., M.D., F.R.C.P., and A. RENDLE SHORT, M.D., B.S., B.Sc., F.R.C.S.; 1943. Bristol: John Wright and Sons Limited. 8¼″ × 5½″, pp. 432, with 60 figures and 64 plates. Price: 25s. net.

"THE MEDICAL ANNUAL" for 1943 is published in its usual form, and contains useful summaries of the many valuable advances brought about in the last year.

There is an interesting little section on suture materials in which it is pointed out that there has been a revival of the non-absorbable varieties, and the virtues of cotton and stainless steel wire are extolled. Another section gives interesting facts about cross-infection in wards, and shows how dust on blankets has often been incriminated; dressing of wounds by teams is described. A very interesting section deals with chemotherapy; a full description of recent work on antibacterial products of fungi, including penicillin, is followed by description of the bacteriology, clinical efficacy *et cetera* of gramicidin, tyrocidin, sulphadiazine, sulphamethazine, sulphapyrazine, sulphaguanidine, succinylsulphathiazole and other compounds. Under the heading "Blood Transfusion" the interesting recent work on the Rhesus factor is included, and its importance in *erythroblastosis fœtalis* and blood transfusion compatibility is stressed. In surgery of the rectum methods of dealing with prolapse are discussed, and reference is made to an operation in which the approach is through the abdomen. Plastic surgery includes a discussion by Sir Harold Gillies and J. B. Cuthbert, in which is included a number of illustrations of the treatment of burns of the hand. A discussion of the treatment of burns of war by C. P. G. Wakeley gives illustrations of chemical and gas burns, and discusses, among others, tanning, irrigation and wax bath methods of treatment. Lanoline is advocated in the after-treatment of burns.

In all, as usual there is much of interest on all topics of medicine, flavoured by the comments of a distinguished array of contributors.

Medical Progress Annual. Edited by ROBERT N. NYE, M.D.; Volume III; 1942. Springfield, Illinois: Charles C. Thomas. London: Baillière, Tindall and Cox. 9″ × 6″, pp. 691. Price: $5.00.

THE third volume of the "Medical Progress Annual", edited by Robert N. Nye, the managing editor of *The New England Journal of Medicine*, and published by Charles C. Thomas, has come to hand.

This volume (1942) is a series of reports on recent accepted advances in diagnosis and treatment. Although the greater part of the book deals with advances in medicine, about one hundred pages are devoted to surgical subjects. Chapters of special surgical interest are: "The Surgery of the Abdomen", by Arthur W. Allen, lecturer in surgery, Harvard Medical School; "Surgical Care and Operative Technic", by John D. Stewart, professor of surgery, University of Buffalo; "Practical Aspects of Surgical Shock", by J. Englebert Dunphy, instructor in surgery, Harvard Medical School; "Surgery of the Sympathetic Nervous System", by Reginald Smithwick, of the Harvard Medical School; "Thoracic Surgery", by Edward D. Churchill, John Homans Professor of Surgery, Harvard Medical School.

This book contains up-to-date information in almost all branches of medicine, and because it keeps the surgeon abreast of advances in other branches of medicine as well as his own, it is a book that he should have and read.

Clinical Roentgenology of the Cardiovascular System. By HUGO ROESLER, M.D., F.A.C.P.; Second Edition; 1943. Springfield, Illinois: Charles C. Thomas; London: Baillière, Tindall and Cox. 9¾″ × 6¼″, pp. 497, with 337 illustrations. Price: $7.50.

So favourably was the first edition received that it is not surprising that only five years have elapsed before it is necessary to publish the second edition of this authoritative work by Hugo Roesler, who is cardiologist and associate professor of roentgenology at the Temple University Hospital, Philadelphia.

Since the days of Benjamin Rush, Franklin's "City of Brotherly Love" has been a famous centre of medical thought and teaching. Here Osler's fame developed, and it was at the great institution, now known as the University of Pennsylvania School of Medicine, that the first medical diploma issued in America was granted in 1768. Also in this city are the Jefferson Medical College and the Hahnemann Medical College, founded in 1825 and 1848 respectively, both large schools with distinguished faculties and many hundreds of students drawn from all quarters of the United States.

Though the Temple University School of Medicine is considerably younger, for it was opened as late as 1901, a farseeing board of trustees has gathered into its faculty many distinguished men, to mention only Chevalier Jackson, C. L. Brown, Temple Fay,

Hugo Roesler and Edwin Chamberlain (the last mentioned being its brilliant professor of roentgenology, who has done so much to raise the status of his specialty). On this account Temple as a medical school now occupies a high position in American medicine.

Roesler began his cardiology in Vienna in the tradition of the great Wenckebach, though most of the original work described in "Clinical Roentgenology of the Cardio-vascular System" has been carried out during the past decade in Philadelphia. Here, as the preface acknowledges, the author has had the rare privilege of close association with Edwin Chamberlain, who has devoted much of his time and incomparable energy to the realization of the true concept that the radiologist should hold the position of consulting physician. Roesler, primarily a clinician, is in strong agreement with this viewpoint, which presupposes the radiologist to be as interested in the anatomy, physiology, pathology and clinical aspects of any condition requiring X-ray investigation as he is in the X-ray film *per se* or in its preceding fluoroscopy. Roesler's principle throughout this work has been the correlation of all these aspects, and that is why it has achieved the acclamation of both clinicians and radiologists alike.

This new edition embodies a considerably enlarged text, many more figures and even fuller references, which now total 2,575; it is thus a veritable encyclopædia of the subject.

Of the many additions, attention can be drawn only to one, which may at first sight appear of minor importance, though it is really a *sine qua non* for the successful employment of X rays in the cardio-vascular sphere. We refer to the significance of accommodation and dark adaptation of the eyes preparatory to the fluoroscopy which is such an essential preliminary to the exposing of films. As in gastro-intestinal work, so in cardiac radiology (where fluoroscopy is more important than radiography), the film is after all only the record—though permanent of course—of an organ's silhouette taken at one particular instant of one particular phase of its particular peristaltic activity. Furthermore, this silhouette, it must be remembered, is influenced by similar factors operating in adjacent organs. Because of these considerations, the exact comparison of cardiac radiograms—in an endeavour to evaluate minor structural changes—must be made with caution.

The author wisely stresses the fact that dark adaptation of the eyes—which includes intensity discrimination and visual acuity, corresponding roughly to contrast and sharpness in X-ray films—cannot be satisfactorily developed under twenty to thirty minutes. By this time visual sensitivity has increased one thousandfold, so the folly is apparent of impatiently commencing fluoroscopy too soon after the eyes have been exposed to white light, though adaptation takes a slightly shorter time if the transition is made from artificial light instead of daylight.

It is not twenty-five years since James Mackenzie wrote: "Indeed I am doubtful if any X-ray examination of the heart has ever thrown the slightest light on any cardiac condition"; but one has little doubt that this great Scot, were he living today, would receive Roesler's splendid work with warm and thankful approval, for its every statement is documented with the results of precise radiological observation against a background of true cardiological erudition.

The Hospital Care of the Surgical Patient. By GEORGE CRILE, JUNIOR, M.D., and FRANKLIN L. SHIVELY, JUNIOR, M.D.; 1943. Springfield, Illinois: Charles C. Thomas; London: Baillière, Tindall and Cox. 8½" × 5½", pp. 199, with 21 illustrations. Price: $2.50.

THIS small volume admirably succeeds in effecting a standardization of hospital treatment and will be valuable to both junior and senior medical officers. It helps to clarify various difficulties encountered in treatment of hospital patients, and emphasizes the importance of pre-operative and post-operative treatment and the relationship of this to surgical shock.

Too much importance cannot be paid to the enigma of surgical shock, and an attempt to deal with it by combining clinical, physiological and technical principles is an important progress in the study of the problem. The management of every surgical complication likely to be encountered is fully dealt with, and as well, the newer procedures in treatment are enumerated. The small chapter on the more commonly used drugs and their dosage and data supplies a very much needed classification which will be welcomed by many busy practitioners.

This will be an excellent reference book because it is well tabulated, and there is need for such a book at the present time when less attention than usual can be given to textbooks, journals and refresher courses.